THE

WORKS OF ARISTOTLE

TRANSLATED INTO ENGLISH

DE PARTIBUS
ANIMALIUM

OXFORD
AT THE CLARENDON PRESS

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TRANSLATED BY

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TO

THE MEMORY

OF

EDWARD POSTE

PREFACE

THIS translation is a revised version of one made by me very many years ago and published in 1882, with introductory essays and very copious annotation. Exigencies of space have necessitated the omission of the former and a very great abridgement of the latter, while the translation itself has been largely altered and corrected. It still, however, remains as before, a very free version; for it is not intended to meet the linguistic requirements of the critical Greek scholar so much as those of the student of biological history, to whom a treatise that is the earliest extant attempt to assign its function to each several organ of the animal body cannot but be of great interest. Such being my main object, I have not hesitated to transfer clauses, or even an entire sentence, when by such transposition the argument can be made less obscure or more consecutive, and have ventured in no few cases to suggest new readings or adopt new readings suggested by others, when such readings are in my judgement called for by the context.

Bekker's text has been followed as a rule, and any departure from it is mentioned in a note. If there be MS. authority for the departure the letter designating the MS. is added, as 'omitting *ψυχρόν* (Z)'. If the new reading be one suggested by some other person, the name of that person is given, as 'For *συστάν* read *συνιστάν* (Platt)'. For other new readings I am myself responsible.

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SYNOPSIS

BOOK I

1 Every[1] systematic science, the humblest and the noblest 639a alike, seems to admit of two distinct kinds of proficiency; one of which may be properly called scientific knowledge of the subject, while the other is a kind of educational acquaintance with it. For an educated man should be able to form a fair off-hand judgement as to the goodness or badness of the method used by a professor in his exposition. To be educated is in fact to be able to do this; and even the man of universal education we deem to be such in virtue of his having this ability. It will, however, of course, be understood that we only ascribe universal education to one who in his own individual person is thus critical in all or nearly all branches of knowledge, and not to one who has a like ability merely in some special subject. For it is possible for a man to have this competence in some one branch of knowledge without having it in all.

It is plain then that, as in other sciences, so in that which inquires into nature, there must be certain canons, by reference to which a hearer shall be able to criticize the method of a professed exposition, quite independently of the question whether the statements made be true or false. Ought we, for instance (to give an illustration of what I mean), to begin by discussing each separate species—man, lion, ox, and the like—taking each kind in hand independently of the rest, or ought we rather to deal first

[1] This treatise, known to us as 'On the Parts of Animals', is referred to by A. himself (*G. A.* v. 3. 782a 21) as 'On the Causes of the Parts of Animals'. It is professedly (ii. 1. 646a 11) an inquiry as to how far the existence and structure of each part are due to Necessity and how far to Design. Owing, however, to the giant share ascribed by A. to the latter cause, the treatise becomes one on the functions of the parts rather than on their causes, and might almost be styled, as was Galen's later work, a treatise *De Usu Partium*.

with the attributes which they have in common in virtue of some common element of their nature, and proceed from this as a basis for the consideration of them separately? For genera that are quite distinct yet oftentimes present many identical phenomena, sleep, for instance, respiration, growth, decay, death,[1] and other similar affections and conditions, which may be passed over for the present, as we are not yet prepared to treat of them with clearness and precision. Now it is plain that if we deal with each species independently of the rest, we shall frequently be obliged to repeat the same statements over and over again; for horse and dog and man present, each and all, every one of the phenomena just enumerated. A discussion therefore of the attributes of each such species separately[2] would necessarily involve frequent repetitions as to characters, themselves identical but recurring in animals specifically distinct. (Very possibly also there may be other characters
639b which, though they present specific differences, yet come under one and the same category. For instance, flying, swimming, walking, creeping, are plainly specifically distinct, but yet are all forms of animal progression.) We must, then, have some clear understanding as to the manner in which our investigation is to be conducted; whether, I mean, we are first to deal with the common or generic characters, and afterwards to take into consideration special peculiarities; or whether we are to start straight off with the ultimate species. For as yet no definite rule has been laid down in this matter. So also there is a like uncertainty as to another point now to be mentioned. Ought the writer who deals with the works of nature to follow the plan adopted by the mathematicians in their astronomical demonstrations, and after considering the phenomena presented by animals, and their several parts, proceed subsequently to treat of the causes and the reason why; or ought he to follow some other method? And when these

[1] All of these, be it noted, as also the modes of progression mentioned a few sentences later on, were made subjects of special treatises by A.

[2] Reading τὰ συμβεβηκότα for τῶν συμβεβηκότων.

questions are answered, there yet remains another. The causes concerned in the generation of the works of nature are, as we see, more than one. There is the final cause and there is the motor cause. Now we must decide which of these two causes comes first, which second. Plainly, however, that cause is the first which we call the final one. For this is the Reason, and the Reason forms the starting-point, alike in the works of art and in works of nature. For consider how the physician or how the builder sets about his work. He starts by forming for himself a definite picture, in the one case perceptible to mind, in the other to sense, of his end—the physician of health, the builder of a house—and this he holds forward as the reason and explanation of each subsequent step that he takes, and of his acting in this or that way as the case may be. Now in the works of nature the good end and the final cause is still more dominant than in works of art such as these, nor is necessity a factor with the same significance in them all; though almost all writers, while they try to refer their origin to this cause, do so without distinguishing the various senses in which the term necessity is used. For there is absolute necessity, manifested in eternal phenomena; and there is hypothetical necessity, manifested in everything that is generated by nature as in everything that is produced by art, be it a house or what it may. For if a house or other such final object is to be realized, it is necessary that such and such material shall exist; and it is necessary that first this and then that shall be produced, and first this and then that set in motion, and so on in continuous succession, until the end and final result is reached, for the sake of which each prior thing is produced and exists. As with these productions of art, so also is it with the productions of nature. The mode of necessity, however, and the mode of ratiocination are different in natural science[1] from what 640a
they are in the theoretical sciences;[2] of which we have

[1] We might add, 'and in art.'

[2] A. divides the sciences into three groups (*Metaph.* E. 1). Firstly, the *Theoretical*, which are purely intellectual and not concerned with action. In this are comprised Metaphysics, Physics, and Mathematics. Secondly the *Practical*; and thirdly, the *Constructive or Artistic.*

spoken elsewhere. For in the latter the starting-point is that which is; in the former that which is to be. For it is that which is yet to be—health, let us say, or a man—that, owing to its being of such and such characters, necessitates the pre-existence or previous production of this and that antecedent; and not this or that antecedent which, because it exists or has been generated, makes it necessary that health or a man is in, or shall come into, existence. Nor is it possible to trace back the series of necessary antecedents to a starting-point, of which you can say that, existing itself from eternity, it has determined their existence as its consequent. These however, again, are matters that have been dealt with in another treatise. There too it was stated in what cases absolute and hypothetical necessity exist; in what cases also the proposition expressing hypothetical necessity is simply convertible, and what cause it is that determines this convertibility.[1]

The Practical and the Artistic comprehend action as well as intelligence; but differ from each other, in that the Practical have no other result than the action itself; whereas the Constructive or Artistic, when the action is over, leave as its result a substantial product.

The contrast in the text is between the theoretical and the constructive sciences; among which latter, A. here inconsistently includes ἡ φυσική; and the points of contrast are as follows. The theoretical philosopher starts from certain eternal facts or verities (τὸ ὄν)—the mathematician for instance from his axioms—and proceeds to deduce from these those consequences which are linked to them by absolute necessity. The artist, on the other hand, or nature, the chief of artists, starts from an ideal conception, not yet existent in matter, but to be realized in the future (τὸ ἐσόμενον). Starting from this, he reasons backwards through the antecedent steps that are necessary, if the conception is to be realized. The realization of my conception E, he says, requires first the realization of D; if D is to be produced, there must previously be C; C again requires B for its production; and so farther and farther back, until he reaches a link in the chain of antecedents, let us say A, the material production of which is within his power. Here the ratiocination ceases, and construction begins. He produces A; then by means of A produces B, from B produces C, and so on, retracing his previous steps, until he reaches E, the conception of which was his starting-point, as its material realization is his end.

[1] (Cf. *De G. et C.* ii. 9–11.) The following is a brief abstract of A.'s views. The only motion capable of being eternal is motion in a circle; and the only element endowed with a rotatory motion is the celestial aether. The heavenly bodies consist of this; and they alone are individually eternal. The Divinity, however, wishing to give the things of earth as near an approach to eternity as is compatible with their being made of other elements than aether, caused their motions

Another matter which must not be passed over without consideration is, whether the proper subject of our exposition is that with which the ancient writers concerned themselves, namely, what is the process of formation of each animal; or whether it is not rather, what are the characters of a given creature when formed. For there is no small difference between these two views. The best course appears to be that we should follow the method already mentioned, and begin with the phenomena presented by each group of animals, and, when this is done, proceed afterwards to state the causes of those phenomena, and to deal with their evolution. For elsewhere, as for instance in house building, this is the true sequence. The plan of the house, or the house, has this and that form; and because it has this and that form, therefore is its construction carried out in this or that manner. For the process of evolution is for the sake of the thing finally evolved, and not this for the sake of the process. Empedocles, then, was in error when he said that many of the characters presented by animals were merely the results of incidental occurrences during their development; for in-

to be so affected by that of the celestial bodies as to simulate rotation in the only way possible, namely by a cyclical arrangement of their serial phenomena. Not only is this manifested in the periodicity of many phenomena (*G. A.* iv. 10. 777b 16), but still more in the successive stages of the evolution of organisms, these stages being so arranged as to form a circle. Germ, foetus, infant, man, and then germ again, and so on in eternal succession. Thus a simulacrum of eternity is impressed on even perishable things in the only way possible for them (*De An.* ii. 4. 415b 4; *G. A.* ii. 1. 731b 32); an eternity, however, which differs from that of the celestial bodies, in that it does not attach to the individual but to the species. For in the cycle—germ, foetus, man, germ—it is not the same germ, but only a similar one, in which the circle is completed. Each term in such a cycle is at once the antecedent and the consequent of all the rest. Man necessarily presupposes germ, and germ as necessarily presupposes man. Any hypothetical proposition then that states the necessary relation of any two of the terms—e.g. if there is to be a man there must necessarily be a germ—is capable of simple conversion—viz. if there is to be a germ there must necessarily be a man.

By the 'propositions expressing hypothetical necessity and capable of simple conversion' A. means, then, all those in which two stages in the cyclical evolution of an organism are placed as antecedent and consequent. By the 'cause which determines this' he may mean either the action of the heavenly bodies upon terrestrial bodies; or possibly, going a stage farther back, the purpose of the Divinity in the construction of the world.

stance, that the backbone was divided as it is into vertebrae, because it happened to be broken owing to the contorted position of the foetus in the womb. In so saying he overlooked the fact that propagation implies a creative[1] seed endowed with certain formative properties. Secondly, he neglected another fact, namely, that the parent animal pre-exists, not only in idea, but actually in time. For man is generated from man; and thus it is the possession of certain characters by the parent that determines the development of like characters in the child. The same statement holds good also for the operations of art, and even for those which are apparently spontaneous.[2] For the same result as is produced by art may occur spontaneously. Spontaneity, for instance, may bring about the restoration of health. The products of art, however, require the pre-existence of an efficient cause homogeneous with themselves, such as the statuary's art, which must necessarily precede the statue; for this cannot possibly be produced spontaneously. Art indeed consists in the conception of the result to be produced before its realization in the material. As with spontaneity, so with chance;[3] for

[1] For *συστάν* read *συνιστάν* (Platt).

[2] No reason is here given as to how the desirable result of Chance or Spontaneity can be said to occur for the sake of such end. The explanation seems to be as follows:—

In the living body there are series of concatenated motions, established by nature or habit, to produce each some desirable end. If any one of these motions be set a-going, the rest of the series follow automatically in due succession till the end is attained (*ὅταν ἀρχὴ γένηται κινήσεως, ὥσπερ ἐν τοῖς αὐτομάτοις θαύμασι, συνείρεται τὸ ἐφεξῆς*, *G. A.* ii. 5. 741 b 8). Such a series is that which terminates in Health, and its final terms are Heat, Uniform bodily condition (*ὁμαλότης*), Health. The man of Art, i. e. the physician, says, in order to restore Health I must obtain *ὁμαλότης*; to obtain this Heat is required; Heat again will follow on Friction. Here then he has come to something within his power. He applies Friction, and Heat, Equable Condition, Health follow in due order. But Friction may be applied by mere Chance and set the mechanism going that ends in Health. In such case the result may be said to be produced *intentionally*, as it is produced by machinery intentionally set up by nature with a view to that end. It is only in the case of bodies that possess such inherent capacity for self-motion (*οἷα κινεῖσθαι ὑφ' αὑτῆς*) that chance can do the work of Art. Results that Art produces from a purely inert material, e.g. a statue, are quite beyond the power of Chance. Cf. *Phys.* ii. 4–6, *Metaph.* Z. 7–9.

[3] Accident is called Chance—or preferably Luck—when the accidental

this also produces the same result as art, and by the same process.

The fittest mode, then, of treatment is to say, a man has such and such parts, because the conception of a man includes their presence, and because they are necessary conditions of his existence, or, if we cannot quite say this, which would be best of all, then the next thing to it, namely, that it is either quite[1] impossible for him to exist without them, or, at any rate, that it is better for him that they should be there; and their existence involves the existence of other antecedents. Thus we should say, because man 640b
is an animal with such and such characters, therefore is the process of his development necessarily such as it is; and therefore is it accomplished in such and such an order, this part being formed first, that next, and so on in succession; and after a like fashion should we explain the evolution of all other works of nature.

Now that with which the ancient writers, who first philosophized about Nature, busied themselves, was the material principle and the material cause. They inquired what this is, and what its character; how the universe is generated out of it, and by what motor influence, whether, for instance, by antagonism or friendship, whether by intelligence or spontaneous action, the substratum of matter being assumed to have certain inseparable properties; fire, for instance, to have a hot nature, earth a cold one; the former to be light, the latter heavy. For even the genesis of the universe is thus explained by them. After a like fashion do they deal also with the development of plants and of animals. They say, for instance, that the water[2] contained in the body causes by its currents the formation of the stomach and the other receptacles of food or of excretion; and that the breath by its passage breaks open the outlets of the nostrils; air and water being the materials of which

agent acts with intention, though not with the intention of producing the result that actually occurs. It is called Spontaneity when the agent has no intention at all. It is the intermixture of semi-intention that gives force to the line *τύχη τέχνην ἔστερξε καὶ τέχνη τύχην*.

[1] For ὅλως ὅτι read ὅτι ὅλως (Z).

[2] Omitting ὅτι.

bodies are made; for all represent nature as composed of such or similar substances.

But if men and animals and their several parts are natural phenomena, then the natural philosopher must take into consideration not merely the ultimate substances of which they are made, but also flesh, bone, blood, and all the other homogeneous parts; not only these, but also the heterogeneous parts, such as face, hand, foot; and must examine how each of these comes to be what it is, and in virtue of what force. For to say what are the ultimate substances out of which an animal is formed, to state, for instance, that it is made of fire or earth, is no more sufficient than would be a similar account in the case of a couch or the like. For we should not be content with saying that the couch was made of bronze or wood or whatever it might be, but should try to describe its design or mode of composition in preference to the material; or, if we did deal with the material, it would at any rate be with the concretion of material and form. For a couch is such and such a form embodied in this or that matter, or such and such a matter with this or that form; so that its shape and structure must be included in our description. For the formal nature is of greater importance than the material nature.

Does, then, configuration and colour constitute the essence of the various animals and of their several parts? For if so, what Democritus says will be strictly correct. For such appears to have been his notion. At any rate he says that it is evident to every one what form it is that makes the man, seeing that he is recognizable by his shape and colour. And yet a dead body has exactly the same configuration as a living one; but for all that is not a man. So also no hand of bronze or wood or constituted in any but the appropriate way can possibly be a hand in more than name.
641a For like a physician in a painting, or like a flute in a sculpture, in spite of its name it will be unable to do the office which that name implies. Precisely in the same way no part of a dead body, such I mean as its eye or its hand, is really an eye or a hand. To say, then, that shape and colour constitute the animal is an inadequate statement,

and is much the same as if a woodcarver were to insist that the hand he had cut out was really a hand. Yet the physiologists, when they give an account of the development and causes of the animal form, speak very much like such a craftsman. What, however, I would ask, are the forces by which the hand or the body was fashioned into its shape? The woodcarver will perhaps say, by the axe or the auger; the physiologist, by air and by earth. Of these two answers the artificer's is the better, but it is nevertheless insufficient. For it is not enough for him to say that by the stroke of his tool this part was formed into a concavity, that into a flat surface; but he must state the reasons why he struck his blow in such a way as to effect this, and what his final object was; namely, that the piece of wood should develop eventually into this or that shape. It is plain, then, that the teaching of the old physiologists is inadequate, and that the true method is to state what the definitive characters are that distinguish the animal as a whole; to explain what it is both in substance and in form, and to deal after the same fashion with its several organs; in fact, to proceed in exactly the same way as we should do, were we giving a complete description of a couch.

If now this something that constitutes the form of the living being be the soul, or part of the soul, or something that without the soul cannot exist; as would seem to be the case, seeing at any rate that when the soul departs, what is left is no longer a living animal, and that none of the parts remain what they were before, excepting in mere configuration, like the animals that in the fable are turned into stone; if, I say, this be so, then it will come within the province of the natural philosopher to inform himself concerning the soul, and to treat of it, either in its entirety, or, at any rate, of that part of it which constitutes the essential character of an animal; and it will be his duty to say what this soul or this part of a soul is; and to discuss the attributes that attach to this essential character, especially as nature is spoken of in two senses, and the nature of a thing is either its matter or its essence; nature as essence includ-

ing both the motor cause and the final cause. Now it is in the latter of these two senses that either the whole soul or some part of it constitutes the nature of an animal; and inasmuch as it is the presence of the soul that enables matter to constitute the animal nature, much more than it is the presence of matter which so enables the soul, the inquirer into nature is bound on every ground to treat of the soul rather than of the matter. For though the wood of which they are made constitutes the couch and the tripod, it only does so because it is capable of receiving such and such a form.

What has been said suggests the question, whether it is the whole soul or only some part of it, the consideration of which comes within the province of natural science. Now if it be of the whole soul that this should treat, then there
641b is no place for any other philosophy beside it. For as it belongs in all cases to one and the same science to deal with correlated subjects—one and the same science, for instance, deals with sensation and with the objects of sense—and as therefore the intelligent soul and the objects of intellect, being correlated, must belong to one and the same science, it follows that natural science will have to include the whole universe in its province. But perhaps it is not the whole soul, nor all its parts collectively, that constitutes the source of motion; but there may be one part, identical with that in plants, which is the source of growth, another, namely the sensory part, which is the source of change of quality, while still another, and this not the intellectual part, is the source of locomotion. I say not the intellectual part; for other animals than man have the power of locomotion, but in none but him is there intellect. Thus then it is plain that it is not of the whole soul that we have to treat. For it is not the whole soul that constitutes the animal nature, but only some part or parts of it. Moreover, it is impossible that any abstraction can form a subject of natural science, seeing that everything that Nature makes is means to an end. For just as human creations are the products of art, so living objects are manifestly the products of an analogous cause or principle, not external but internal,

derived like the hot and the cold[1] from the environing universe. And that the heaven, if it had an origin, was evolved and is maintained by such a cause, there is therefore even more reason to believe, than that mortal animals so originated. For order and definiteness are much more plainly manifest in the celestial bodies than in our own frame; while change and chance are characteristic of the perishable things of earth. Yet there are some who, while they allow that every animal exists and was generated by nature, nevertheless hold that the heaven was constructed to be what it is by chance and spontaneity; the heaven, in which not the faintest sign of hap-hazard or of disorder is discernible! Again, whenever there is plainly some final end, to which a motion tends should nothing stand in the way, we always say that such final end is the aim or purpose of the motion; and from this it is evident that there must be a something or other really existing, corresponding to what we call by the name of Nature. For a given germ does not give rise to any chance living being, nor spring from any chance one; but each germ springs from a definite parent and gives rise to a definite progeny. And thus it is the germ that is the ruling influence and fabricator of the offspring. For these it is by nature, the offspring being at any rate that which in nature will spring from it. At the same time the offspring is anterior[2] to the germ; for germ and perfected progeny are related as the developmental process and the result.[3] Anterior, however, to both germ and product is the organism from which the germ was derived. For every germ implies two organisms, the parent and the progeny. For germ or seed is both the seed of the organism from which it came, of the horse, for instance, from which it was derived, and the seed of the organism that will eventually arise from it, of the mule, for example, which is developed from the seed of the horse. The same seed then is the seed both of the horse and of the mule, though in different ways as here set forth.

[1] And the other material elements of our bodies.
[2] That is to say, in the order of thought.
[3] And result is in thought anterior to evolution.

Moreover, the seed is potentially that which will spring from it, and the relation of potentiality to actuality we know.[1]

642a There are then two causes, namely, necessity and the final end. For many things are produced, simply as the results of necessity. It may, however, be asked, of what mode of necessity[2] are we speaking when we say this. For it can be of neither of those two modes which are set forth in the philosophical treatises.[3] There is, however, the third mode, in such things at any rate as are generated. For instance, we say that food is necessary; because an animal cannot possibly do without it. This third mode is what may be called hypothetical necessity. Here is another example of it. If a piece of wood is to be split with an axe, the axe must of necessity be hard; and, if hard, must of necessity be made of bronze or iron. Now exactly in the same way the body, which like the axe is an instrument—for both the body as a whole and its several parts individually have definite operations for which they are made—just in the same way, I say, the body, if it is to do its work, must of necessity be of such and such a character, and made of such and such materials.

It is plain then that there are two modes of causation, and that both of these must, so far as possible, be taken into account in explaining the works of nature, or that at any rate an attempt must be made to include them both;[4] and that those who fail in this tell us in reality

[1] We know, that is, to be that of consequent to antecedent.

[2] As A. has fully explained what he means by Hypothetical Necessity only a few pages back, it is strange that he should now deal with it again in terms that seem to imply that he is stating something quite new. Very possibly the whole of this long paragraph is an interpolation.

[3] Elsewhere (*Metaph.* iv. 5) A. speaks of three kinds of necessity, Absolute necessity, Necessity of coercion (as when a weaker agent is constrained by a stronger one), and Hypothetical necessity. There is also another passage (*Phys.* ii. 9) in which he deals with necessity, and distinguishes, as in the text, two kinds, Absolute and Hypothetical. Plainly, however, it can be to neither of these passages that he is now referring. The passage wherever it is, or was, must have been one in which the two modes of necessity distinguished from each other were Absolute and Coercive necessity. It may perhaps have been contained in the lost dialogue on Philosophy; concerning which see Heitz, *Die verlor. Schrift. d. Arist.* 179.

[4] Reading εἰ δὲ μή, πειρᾶσθαί γε ποιεῖν τοῦτο, δῆλον.

nothing about nature. For primary[1] cause constitutes the nature of an animal much more than does its matter. There are indeed passages in which even Empedocles hits upon this, and following the guidance of fact, finds himself constrained to speak of the ratio (ὁ λόγος) as constituting the essence and real nature of things. Such, for instance, is the case when he explains what is a bone. For he does not merely describe its material, and say it is this one element, or those two or three elements, or a compound of all the elements, but states the ratio (ὁ λόγος) of their combination.[2] As with a bone, so manifestly is it with the flesh and all other similar parts.

The reason why our predecessors failed in hitting upon this method of treatment was, that they were not in possession of the notion of essence, nor of any definition of substance. The first who came near it was Democritus, and he was far from adopting it as a necessary method in natural science, but was merely brought to it, spite of himself, by constraint of facts. In the time of Socrates a nearer approach was made to the method. But at this period men gave up inquiring into the works of nature, and philosophers diverted their attention to political science and to the virtues which benefit mankind.

Of the method itself the following is an example. In dealing with respiration we must show that it takes place for such or such a final object; and we must also show that this and that part of the process is necessitated by this and that other stage of it. By necessity we shall sometimes mean hypothetical necessity, the necessity, that is, that the requisite antecedents shall be there, if the final end is to be reached; and sometimes absolute necessity, such necessity as that which connects substances and their inherent properties and characters. For the alternate discharge and re-

[1] i.e. the final cause; for, as said earlier in the chapter, 'that cause is the first which we call the final.'

[2] Both Empedocles and Aristotle can speak of the λόγος of a bone, but in different senses; Empedocles meaning no more than the proportion or ratio of the several component parts of bone; while Aristotle means the reason or cause of such composition, and professes to believe that Empedocles meant something of the same kind.

entrance of heat and the inflow of air are necessary if we are to live. Here we have at once a necessity in the former of
642b the two senses. But the alternation of heat and refrigeration produces of necessity an alternate admission and discharge of the outer air, and this is a necessity of the second kind.[1]

In the foregoing we have an example of the method which we must adopt, and also an example of the kind of phenomena, the causes of which we have to investigate.

Some[2] writers propose to reach the definitions of the 2
ultimate forms of animal life by bipartite division. But this method is often difficult, and often impracticable.

Sometimes the final differentia of the subdivision is sufficient by itself, and the antecedent differentiae are mere surplusage. Thus in the series Footed, Two-footed, Cleft-footed,[3] the last term is all-expressive by itself, and to append the higher terms is only an idle iteration.

Again it is not permissible to break up a natural group, Birds for instance, by putting its members under different bifurcations, as is done in the published dichotomies, where some birds are ranked with animals of the water, and others placed in a different class. The group Birds and the group Fishes happen to be named, while other natural groups have no popular names; for instance, the groups that we may call Sanguineous and Bloodless are not known popularly by any designations. If such natural groups are not to be broken up, the method of Dichotomy cannot be employed, for it necessarily involves such breaking up and dislocation. The group of the Many-footed, for instance,

[1] This passage defies all other than a paraphrastic rendering with some expansion.

[2] Alluding to Plato's method of dividing downwards until by successive bifurcations the infima species is at last reached. Examples of this method, *abscissio infiniti*, will be found in the *Sophistes* and *Politicus*. These are apparently the 'published dichotomies' of which A. speaks; and it is to them that his criticisms in this and the two next chapters have immediate reference. The main interest of these chapters to the biologist lies in the evidence they give that the idea of natural classification had occurred to Aristotle, their whole drift indeed being to uphold the claims of natural as opposed to artificial systems.

[3] Omitting *ἄπουν*.

would, under this method, have to be dismembered, and some of its kinds distributed among land animals, others among water animals.

3 Again, privative terms inevitably form one branch of dichotomous division, as we see in the proposed dichotomies. But privative terms in their character of privatives admit of no subdivision. For there can be no specific forms of a negation, of Featherless for instance or of Footless, as there are of Feathered and of Footed. Yet a generic differentia must be subdivisible; for otherwise what is there that makes it generic rather than specific? There are to be found generic, that is specifically subdivisible, differentiae; Feathered for instance and Footed. For feathers are divisible into Barbed and Unbarbed, and feet into Manycleft, and Twocleft, like those of animals with bifid hoofs, and Uncleft or Undivided, like those of animals with solid hoofs. Now even with differentiae capable of this specific subdivision it is difficult enough so to make the classification, as that each animal shall be comprehended in some one subdivision and in not more than one; but far more difficult, nay impossible, is it to do this, if we start with a dichotomy into two contradictories. (Suppose for instance we start with the two contradictories,[1] Feathered and Unfeathered; we shall find that the ant,[2] the glow-worm, and some other animals fall under both divisions.) For each differentia must be presented by some species. There must be some species, therefore, under the privative heading. Now specifically distinct animals cannot 643a
present in their essence a common undifferentiated element, but any apparently common element must really be differentiated. (Bird and Man for instance are both Two-footed, but their two-footedness is diverse and differentiated. So any two sanguineous groups must have some difference in their blood, if their blood is part of their essence.) From

[1] For ἄναιμα read ἐναντία.

[2] The wing of an insect was held by A. to be a feather (πτερόν, not πτέρυξ), differing, however, from the feather of a bird in being without barbs and without shaft (ἄσχιστον and ἄκαυλον) and also in its mode of origin (cf. iv. 6. 682b 18).

this it follows that a privative term, being insusceptible of differentiation, cannot be a generic differentia; for, if it were, there would be a common undifferentiated element in two different groups.

Again, if the species are ultimate indivisible groups, that is, are groups with indivisible differentiae, and if no differentia be common to several groups, the number of differentiae must be equal to the number of species. If a differentia though not divisible could yet be[1] common to several groups, then it is plain that in virtue of that common differentia specifically distinct animals would fall into the same division. It is necessary then, if the differentiae, under which are ranged all the ultimate and indivisible groups, are specific characters, that none of them shall be common; for otherwise, as already said, specifically distinct animals will come into one and the same division. But this would violate one of the requisite conditions, which are as follows. No ultimate group must be included in more than a single division; different groups must not be included in the same division; and every group must be found in some division. It is plain then that we cannot get at the ultimate specific forms of the animal, or any other, kingdom by bifurcate division. If we could, the number of ultimate differentiae would equal the number of ultimate animal forms.[2] For assume an order of beings whose prime differentiae are White and Black.[3] Each of these branches will bifurcate, and their branches again, and so on till we reach the ultimate differentiae, whose number will be four or some other power of two, and will also be the number of the ultimate species comprehended in the order.

(A species is constituted by the combination of differentia and matter.[4] For no part of an animal is purely material or purely immaterial; nor can a body, independently of its condition, constitute an animal or any of its parts, as has repeatedly been observed.)[5]

[1] Omitting μή with Titze.
[2] And that, he implies, is inconceivable.
[3] For τὰ λευκά read τὸ λευκὸν καὶ τὸ μέλαν (Edit. nonnulli).
[4] Reading ἐν τῇ ὕλῃ τὸ εἶδος (Y).
[5] e.g. at i. 1. 641a 19.

Further, the differentiae must be elements of the essence, and not merely essential attributes. Thus if Figure is the term to be divided, it must not be divided into figures whose angles are equal to two right angles, and figures whose angles are together greater than two right angles. For it is only an attribute of a triangle and not part of its essence that its angles are equal to two right angles.

Again, the bifurcations must be opposites, like White and Black, Straight and Bent ; and if we characterize one branch by either term, we must characterize the other by its opposite, and not, for example, characterize one branch by a colour, the other by a mode of progression, swimming for instance.

Furthermore, living beings cannot be divided[1] by the functions common to body and soul, by Flying, for instance, and Walking, as we see them divided in the dichotomies already referred to. For some groups, Ants for instance, 643b fall under both divisions, some ants flying while others do not. Similarly as regards the division into Wild and Tame ; for it also would involve the disruption of a species into different groups. For in almost all species in which some members are tame, there are other members that are wild. Such, for example, is the case with Men, Horses, Oxen, Dogs in India, Pigs, Goats, Sheep ; groups which, if double, ought to have what they have not, namely, different appellations ; and which, if single, prove that Wildness and Tameness do not amount to specific differences. And whatever[2] single element we take as a basis of division the same difficulty will occur.

The method then that we must adopt is to attempt to recognize the natural groups, following the indications afforded by the instincts of mankind, which led them for instance to form the class of Birds and the class of Fishes, each of which groups combines a multitude of differentiae, and is not defined by a single one as in dichotomy. The method of dichotomy is either impossible (for it would put a single group under different divisions or contrary groups

[1] Reading *οὐ δεῖ διαιρεῖν* (Gaza).
[2] Reading *ὁποιᾳοῦν* (Y) and *διαφορᾷ* (EY).

under the same division), or it only furnishes a single ultimate differentia for each species, which either alone or with its series of antecedents has to constitute the ultimate species.

If, again, a new differential character be introduced at any stage into the division, the necessary result is that the continuity of the division becomes merely a unity and continuity of agglomeration, like the unity and continuity of a series of sentences coupled together by conjunctive particles. For instance, suppose we have the bifurcation Feathered and Featherless, and then divide Feathered into Wild and Tame, or into White and Black. Tame and White are not a differentiation of Feathered, but are the commencement of an independent bifurcation, and are foreign to the series at the end of which they are introduced.

As we said then, we must define at the outset by a multiplicity of differentiae. If we do so, privative terms will be available, which are unavailable to the dichotomist.

The impossibility of reaching the definition of any of the ultimate forms by dichotomy of the larger group, as some propose, is manifest also from the following considerations. It is impossible that a single differentia, either by itself or with its antecedents, shall express the whole essence of a species. (In saying a single differentia by itself I mean such an isolated differentia as Cleft-footed ; in saying a single differentia with antecedent I mean, to give an instance, Many-cleft-footed preceded by Cleft-footed.[1] The very continuity of a series of successive differentiae in a division is intended to show that it is their combination that expresses the character of the resulting unit, or ultimate group. But one is misled by the usages of language into imagining that it is merely the final term of the series, Many-cleft-footed for instance, that constitutes the whole differentia, and that the antecedent terms, Footed, Cleft-
644a footed, are superfluous.[2] Now it is evident that such a

[1] For πρὸς τὸ σχιζόπουν read πρὸς τῷ σχιζόπουν (Platt).

[2] In the text as it stands the terms of several distinct series of differentiae are mixed together with much confusion. If, however, we omit ἢ τὸ δίπουν, and substitute σχιζόπουν for πολύπουν, as I have ventured to do in the translation, the terms of only one series—

series cannot consist of many terms. For if one divides and subdivides, one soon reaches the final differential term, but for all that will not have got to the ultimate division, that is, to the species.) No single differentia, I repeat, either by itself or with its antecedents, can possibly express the essence of a species. Suppose, for example, Man to be the animal to be defined; the single differentia will be Cleft-footed, either by itself or with its antecedents, Footed and Two-footed.[1] Now if man was nothing more than a Cleft-footed animal, this single [2] differentia would duly represent his essence. But seeing that this is not the case, more differentiae than this one will necessarily be required to define him; and these cannot come under one division; for each single branch of a dichotomy ends in a single differentia, and cannot possibly include several differentiae belonging to one and the same animal.

It is impossible then to reach any of the ultimate animal forms by dichotomous division.

4 It deserves inquiry why a single name denoting a higher group was not invented by mankind, as an appellation to comprehend the two groups of Water animals and Winged animals. For even these have certain attributes in common.[3] However, the present nomenclature is just. Groups that only differ in degree, and in the more or less of an identical element that they possess, are aggregated under a single class; groups whose attributes are not identical but analogous are separated. For instance, bird differs from bird by gradation, or by excess and defect; some birds have long feathers, others short ones, but all are feathered. Bird and Fish are more remote and only agree

Footed, Cleft-footed, Many-cleft-footed—are used, and the passage becomes intelligible and clear.

[1] If the text be correct, which the many different readings make doubtful, A. is speaking carelessly; for Many-cleft-footed clearly does not imply Two-footed, seeing that many quadrupeds are *πολυσχιδῆ*. Much alteration would be required to make the passage logically accurate. It might, however, be done by reading *ἢ τὸ πολυσχιδὲς μόνον* instead of *ἢ τὸ σχιζόπουν μόνον*, and for *ὑπόπουν δίπουν σχιζόπουν* reading *ὑπόπουν σχιζόπουν πολυσχιδές*; and then *πολυσχιδές* after *ἄνθρωπος*.

[2] Read *αὕτη ἡ μία*.

[3] Omit *καὶ τοῖς ἄλλοις*.

in having analogous organs; for what in the bird is feather, in the fish is scale. Such analogies can scarcely, however, serve universally as indications for the formation of groups, for almost all animals present analogies in their corresponding parts.

The individuals[1] comprised within a species, such as Socrates and Coriscus, are the real existences; but inasmuch as these individuals possess one common specific form, it will suffice to state the universal attributes of the species, that is, the attributes common to all its individuals, once for all, as otherwise there will be endless reiteration, as has already been pointed out.[2]

But as regards the larger groups—such as Birds—which comprehend many species, there may be a question. For on the one hand it may be urged that as the ultimate species represent the real existences, it will be well, if practicable, to examine these ultimate species separately, just as we examine the species Man separately; to examine, that is, not the whole class Birds collectively, but the Ostrich, the Crane, and the other indivisible groups or species belonging to the class.

On the other hand, however, this course would involve repeated mention of the same attribute, as the same attribute is
644b common to many species, and so far would be somewhat irrational and tedious. Perhaps, then, it will be best to treat generically the universal attributes of the groups that have a common nature and contain closely allied subordinate forms, whether they are groups recognized by a true instinct of mankind, such as Birds and Fishes, or groups not popularly known by a common appellation, but withal composed of closely allied subordinate groups; and only to deal individually with the attributes of a single species, when such species—man, for instance, and any other such, if such there be—stands apart from others, and does not constitute with them a larger natural group.

[1] By *τὰ ἔσχατα εἴδη*, if such be the true reading, must here be meant 'the ultimate forms', i. e. the individuals comprised in a species, as rendered above. This, however, seems a scarcely tenable translation of the words, and I prefer, as a possible emendation, that we should read *τὰ ἔσχατα* without *εἴδη*.

[2] Cf. i. 1. 639a 27.

It is generally similarity in the shape of particular organs, or of the whole body, that has determined the formation of the larger groups. It is in virtue of such a similarity that Birds, Fishes, Cephalopoda,[1] and Testacea have been made to form each a separate class. For within the limits of each such class, the parts do not differ in that they have no nearer resemblance than that of analogy—such as exists between the bone of man and the spine of fish—but differ merely in respect of such corporeal conditions as largeness smallness, softness hardness, smoothness roughness, and other similar oppositions, or, in one word, in respect of degree.

We have now touched upon the canons for criticizing the method of natural science, and have considered what is the most systematic and easy course of investigation; we have also dealt with division, and the mode of conducting it so as best to attain the ends of science, and have shown why dichotomy is either impracticable or inefficacious for its professed purposes.

Having laid this foundation, let us pass on to our next topic.

5 Of things constituted by nature some are ungenerated, imperishable, and eternal, while others are subject to generation and decay. The former are excellent beyond compare and divine, but less accessible to knowledge. The evidence that might throw light on them, and on the problems which we long to solve respecting them, is furnished but scantily by sensation; whereas respecting perishable plants and animals we have abundant information, living as we do in their midst, and ample data may be collected concerning all their various kinds, if only we are willing to take sufficient pains. Both departments, however, have their special charm. The scanty conceptions to which we can attain of celestial things give us, from their excellence, more pleasure than all our knowledge of the

[1] A.'s μαλάκια do not correspond to our Mollusca, though often so rendered, but to the limited and well-defined group of Cephalopoda; and the term is so translated in the rest of this treatise.

world in which we live; just as a half glimpse of persons that we love is more delightful than a leisurely view of 645a other things, whatever their number and dimensions. On the other hand, in certitude and in completeness our knowledge of terrestrial things has the advantage. Moreover, their greater nearness and affinity to us balances somewhat the loftier interest of the heavenly things that are the objects of the higher philosophy. Having already treated of the celestial world, as far as our conjectures could reach, we proceed to treat of animals, without omitting, to the best of our ability, any member of the kingdom, however ignoble. For if some have no graces to charm the sense, yet even these, by disclosing to intellectual perception the artistic spirit that designed them, give immense pleasure to all who can trace links of causation, and are inclined to philosophy. Indeed, it would be strange if mimic representations of them were attractive, because they disclose the mimetic skill of the painter or sculptor, and the original realities themselves were not more interesting, to all at any rate who have eyes to discern the reasons that determined their formation. We therefore must not recoil with childish aversion from the examination of the humbler animals. Every realm of nature is marvellous: and as Heraclitus, when the strangers who came to visit him found him warming himself at the furnace in the kitchen and hesitated to go in, is reported to have bidden them not to be afraid to enter, as even in that kitchen divinities were present, so we should venture on the study of every kind of animal without distaste; for each and all will reveal to us something natural and something beautiful. Absence of haphazard and conduciveness of everything to an end are to be found in Nature's works in the highest degree, and the resultant end of her generations and combinations is a form of the beautiful.

If any person thinks the examination of the rest of the animal kingdom an unworthy task, he must hold in like disesteem the study of man. For no one can look at the primordia of the human frame—blood, flesh, bones, vessels, and the like—without much repugnance. Moreover, when

any one of the parts or structures, be it which it may, is under discussion, it must not be supposed that it is its material composition to which attention is being directed or which is the object of the discussion, but the relation of such part to the total form. Similarly, the true object of architecture is not bricks, mortar, or timber, but the house; and so the principal object of natural philosophy is not the material elements, but their composition, and the totality of the form, independently of which they have no existence.

The course of exposition must be first to state the 645b
attributes common to whole groups of animals, and then to attempt to give their explanation. Many groups, as already noticed,[1] present common attributes, that is to say, in some cases absolutely identical affections, and absolutely identical organs,—feet, feathers, scales, and the like; while in other groups the affections and organs are only so far identical as that they are analogous. For instance, some groups have lungs, others have no lung, but an organ analogous to a lung in its place; some have blood, others have no blood, but a fluid analogous to blood,[2] and with the same office. To treat of the common attributes in connexion with each individual group would involve, as already suggested, useless iteration. For many groups have common attributes. So much for this topic.

As every instrument and every bodily member subserves some partial end, that is to say, some special action, so the whole body must be destined to minister to some plenary sphere of action. Thus the saw is made for sawing, for sawing is a function, and not sawing for the saw. Similarly, the body too must somehow or other be made for the soul, and each part of it for some subordinate function, to which it is adapted.

[1] Cf. i. 1. 639a 18 and 27.

[2] A. divides animals into those with and those without blood, meaning exclusively *red* blood. This division into Sanguineous and Bloodless tallies closely with that into Vertebrates and Invertebrates, but not completely. For in Amphioxus, usually classed as vertebrate, the blood is colourless, while it is red in no few invertebrates, e. g. in Planorbis, Arca, Pectunculus, Solen legumen, &c., &c. Possibly it was the red blood in some worms, e. g. those common in pond-mud, that led A. to consider worms generally to be immature eels (*G. A.* iii. 11, 762b 26, *H. A.* vi. 16. 570a 15).

We have, then, first to describe the common functions, common, that is, to the whole animal kingdom, or to certain large groups, or to the members of a species. In other words, we have to describe the attributes common to all animals, or to assemblages, like the class of Birds, of closely allied groups differentiated by gradation, or to groups like Man not differentiated into subordinate groups. In the first case the common attributes may be called analogous, in the second generic, in the third specific.

When a function is ancillary to another, a like relation manifestly obtains between the organs which discharge these functions; and similarly, if one function is prior to and the end of another, their respective organs will stand to each other in the same relation. Thirdly, the existence of these parts involves that of other things as their necessary consequents.[1]

Instances of what I mean by functions and affections are Reproduction, Growth, Copulation, Waking, Sleep, Locomotion, and other similar vital actions. Instances of what I mean by parts are Nose, Eye, Face, and other so-called
646a members or limbs, and also the more elementary parts[2] of which these are made. So much for the method to be pursued. Let us now try to set forth the causes of all vital phenomena, whether universal or particular, and in so doing let us follow that order of exposition which conforms, as we have indicated, to the order of nature.

[1] Reading ἃ τούτων for τῶν. The meaning is plain from other passages. Thus: 'we must not always expect to find such a final cause; for granted the existence in the body of this or that constituent with such and such properties, many results must ensue as necessary results of these properties' (iv. 2. 677a 17); and again, 'everything given by nature is either itself given for an end, or is the incidental accompaniment of something else that is so given' (*De An.* iii. 12. 434a 31). A.'s triple division may be illustrated by an example. (1) The alimentary canal, as a whole, has the elaboration of food for its plenary function. (2) The teeth, gullet, stomach, and intestines, with their several offices, are ancillary to the last. (3) The fatty omentum is held by A. (iv. 3. 677b 22) to be the necessary consequent of the above parts, and to have no distinct function of its own.

[2] Such appears to be the meaning of τῶν ἄλλων; μόρια that are not μέρη; that is homogeneous as contrasted with heterogeneous parts. Cf. ii. 1. 646a 20 note.

BOOK II

1 The nature and the number of the parts of which animals are severally composed are matters which have already been set forth in detail in the book of Researches about Animals. We have now to inquire what are the causes that in each case have determined this composition, a subject quite distinct from that dealt with in the Researches.[1]

Now there are three degrees of composition; and of these the first in order, as all will allow, is composition out of what some call the elements, such as earth, air, water, fire. Perhaps, however, it would be more accurate to say composition out of the elementary forces;[2] nor indeed out

[1] In the *Hist. Animalium* (Books i.–iv. 7) the parts were *described*; their *causes* are now to be considered—a very different subject.

[2] The so-called elements, says A. elsewhere (*De G. et C.* ii. 2), are not simple bodies but compounds, being produced by combinations of the primary forces or active properties of matter. Tangible objects differ from each other in endless ways, as regards colour, taste, smell, &c. (*Meteor.* iv. 10); but they are all either fluid or solid, and all either hot or cold. Everything tangible presents two of these properties; it is either solid or fluid, and either hot or cold. There are then four main elementary properties, and each object possesses two of them. Now among four things there may be six combinations of two and two (συζεύξεις); but the pairing of two directly opposite properties, as of cold and hot, causes them both to disappear; for they neutralize each other. Thus only four combinations remain, and these correspond to the four apparently simple bodies, fire, air, water, earth; solid and hot forming fire; hot and fluid forming air, for air corresponds to vapour; fluid and cold forming water; cold and solid forming earth.

It is evident then why A. holds it more accurate to say composition from the elementary forces rather than from the elements, the former being the components of the latter. It is plain also that when he says 'nor out of all of them', he means to exclude all other properties excepting the four main ones, two of which belong to every tangible object. From these four primary properties, he says, all others are derived, and in contrast to them may be called secondary. As to the mode in which the secondary properties are deducible from the primary ones, cf. *De G. et C.* ii. 2.

It will be noticed that A. uses the adjectival forms, hot, cold, solid, fluid, and not the substantives, heat, fluidity, &c. For he is speaking not of abstract properties, but of concrete substances. His views (*De G. et C.* ii. 1) were as follows. There is one ultimate matter,

of all of these, but out of a limited number of them, as defined in previous treatises. For fluid and solid,[1] hot and cold, form the material of all composite bodies;[2] and all other differences are secondary to these, such differences, that is, as heaviness or lightness, density or rarity, roughness or smoothness, and any other such properties of matter as there may be. The second degree of composition is that by which the homogeneous [3] parts of animals, such as bone,

which forms the universal substratum of all terrestrial things. This matter, however, has no existence in a condition of isolation, but is invariably combined with some or other of the primary properties, heat, fluidity, &c. Thus we have fluid matter, hot matter, solid matter, cold matter; but there is no such thing as simple matter by itself, any more than there is such a thing as fluidity by itself. By hot, cold, solid, fluid, A. means then the universal substratum in a state of heat, coldness, solidity, or fluidity.

[1] The traditional rendering of *ὑγρόν* and *ξηρόν* is Wet or Moist and Dry. They are here rendered Fluid and Solid. For though these terms are, as A. says (ii. 3. 649^b 9), used in several senses, the definitions he gives of them (*De G. et C.* ii. 2. 329^b 30) are distinctly definitions of Fluid and Solid. He defines *ὑγρόν* (fluid) as 'that which has no definite boundary of its own but readily has one imposed upon it', meaning, of course, by the receptacle into which it is poured; while *ξηρόν* (solid) is 'that which has a definite boundary of its own and resists the imposition of another'.

[2] By compound substances A. means all substances made by combinations of the elements. Every such compound, that is every actually existing substance, contains, says A. (*De G. et C.* ii. 8), some proportion of every one of the four elementary substances. The differences between substances depended therefore, not on differences in the elements of which they were made, but on differences in the ever-varying proportions in which these were combined to form them.

A. distinguished clearly enough between chemical combination and mere mixture. In the former, he says (*De G. et C.* i. 10), the combining substances disappear with their properties, and a new substance with new properties arises from their unification. In the latter the mixed substances remain with all their properties, and it is merely the imperfection of our vision which prevents us from seeing the particles of each lying side by side and separate. Had we the eyes of Lynceus we should do so, however intimate the mixture might be. But though A. thus distinguished chemical combination from mechanical mixture, he had no notion of preferential affinities, nor, of course, of combination in definite proportions. The elementary bodies combined with each other with perfect indifference, and in any chance proportions. There was thus no such thing as definite composition, and consequently no such thing as definite properties, in substances. One piece of matter might resemble another more or less, but that it should be identical with it in composition and therefore in properties was, in the infinity of possibilities, so improbable as to be out of the question. It was to this *ἀοριστία τῆς ὕλης* (*G. A.* iv. 7. 778^a 6) that A. ascribed the apparent imperfections in Nature's handiwork.

[3] The division into Homogeneous and Heterogeneous parts corre-

flesh, and the like, are constituted out of the primary substances. The third and last stage is the composition which forms the heterogeneous parts, such as face, hand, and the rest.

Now the order of actual development and the order of logical existence are always the inverse of each other. For that which is posterior in the order of development is antecedent in the order of nature, and that is genetically last which in nature is first.

(That this is so is manifest by induction; for a house does not exist for the sake of bricks and stones, but these materials for the sake of the house; and the same is the case with the materials of other bodies. Nor is induction required to show this. It is included in our conception of generation. For generation is a process from a something to a something; that which is generated having a cause in which it originates and a cause in which it ends. The originating cause is the primary efficient cause, which is something already endowed with tangible existence, while the final cause is some definite form or similar end; for man generates man, and plant generates plant, in each case out of the underlying material.)[1]

In order of time, then, the material and the generative process must necessarily be anterior to the being that is generated; but in logical order the definitive character and 646b
form of each being precedes the material. This is evident if one only tries to define the process of formation. For the definition of house-building includes and presupposes that of the house; but the definition of the house does not

sponds in a general way to the later division into Tissues and Organs; the former, however, including much that we should not call tissue, e.g. the blood, and, in short, any constituent of the body which A. held to be incapable of further structural analysis, being formed directly out of the compound, i.e. the chemical, substances. These Homogeneous parts again were of two kinds, (*a*) simple tissues or stuffs, without any notion of size or shape, e.g. cartilaginous or osseous tissues, and (*β*) simple organs, that is, organs made of a single tissue but with definite form and size, e.g. a cartilage or a bone. In this sense even the heart was homogeneous, being made of a single tissue, viz. flesh, while it was heterogeneous as having a definite shape.

[1] The material substratum is of comparatively small importance; the form is derived from the parent.

include nor presuppose that of house-building; and the same is true of all other productions. So that it must necessarily be that the elementary material exists for the sake of the homogeneous parts, seeing that these are genetically posterior to it, just as the heterogeneous parts are posterior genetically to them. For these heterogeneous parts have reached the end and goal, having the third degree of composition, in which degree generation or development often attains its final term.[1]

Animals, then, are composed of homogeneous parts, and are also composed of heterogeneous parts. The former, however, exist for the sake of the latter. For the active functions and operations of the body are carried on by these; that is, by the heterogeneous parts, such as the eye, the nostril, the whole face, the fingers, the hand, and the whole arm. But inasmuch as there is a great variety in the functions and motions not only of aggregate animals but also of the individual organs, it is necessary that the substances out of which these are composed shall present a diversity of properties. For some purposes softness is advantageous, for others hardness; some parts must be capable of extension, others of flexion. Such properties, then, are distributed separately to the different homogeneous parts, one being soft another hard, one fluid another solid, one viscous another brittle; whereas each of the heterogeneous parts presents a combination of multifarious properties. For the hand, to take an example, requires one property to enable it to effect pressure, and another and different property for simple prehension. For this

[1] The first degree of composition was that of the compound substances; the second that of the homogeneous parts or tissues; the third that of the heterogeneous parts or organs. The evolution, then, of an individual organ has reached its final term when this third stage is attained. But in an animal or a plant, as a rule, there is yet a fourth degree of composition. For the entire organism is made up of a multiplicity of organs. This, however, is not the case with all organisms. The simpler kinds (Aristotle would probably have instanced the Sponge, the Actinia, the Medusa and, among plants, Lichens and Fungi) present no such distinction of parts as allows us to say that they are made up of organs. They are constructed not of organs, but directly out of tissues. Their evolution, therefore, as that of a single organ, ends with the third degree of composition. They are aggregates of the third, not of the fourth, degree.

reason the active or executive parts of the body are compounded out of bones, sinews, flesh, and the like, but not these latter out of the former.

So far, then, as has yet been stated, the relations between these two orders of parts are determined by a final cause. We have, however, to inquire whether necessity may not also have a share in the matter; and it must be admitted that these mutual relations could not from the very beginning have possibly been other than they are. For heterogeneous parts can be made up out of homogeneous parts, either from a plurality of them, or from a single one, as is the case with some of the viscera which, varying in configuration, are yet, to speak broadly, formed from a single homogeneous substance; but that homogeneous substances should be formed out of a combination of heterogeneous parts is clearly an impossibility. For these 647a causes, then, some parts of animals are simple and homogeneous, while others are composite and heterogeneous; and dividing the parts into the active or executive and the sensitive, each one of the former is, as before said, heterogeneous, and each one of the latter homogeneous. For it is in homogeneous parts alone that sensation can occur, as the following considerations show.

Each sense is confined to a single order of sensibles, and its organ must be such as to admit the action of that kind or order. But it is only that which is endowed with a property *in posse* that is acted on by that which has the like property *in esse*, so that the two are the same in kind, and if[1] the latter is single so also is the former. Thus it is that while no physiologists ever dream of saying of the hand or face or other such part that one is earth, another water, another fire, they couple each separate sense-organ with a separate element, asserting this one to be air and that other to be fire.

Sensation, then, is confined to the simple or homogeneous parts. But, as might reasonably be expected, the organ of

[1] Reading *καὶ εἰ ἐκεῖνο ἕν*. If the organ were not a simple homogeneous substance it would be acted on by more than one order of sensibles, which is not the case.

touch, though still homogeneous, is yet the least simple of all the sense-organs. For touch more than any other sense appears to be correlated to several distinct kinds of objects, and to recognize more than one category of contrasts, heat and cold, for instance, solidity and fluidity, and other similar oppositions. Accordingly, the organ which deals with these varied objects is of all the sense-organs the most corporeal,[1] being either the flesh, or the substance which in some animals takes the place of flesh.

Now as there cannot possibly be an animal without sensation, it follows as a necessary consequence that every animal must have some homogeneous parts; for these alone are capable of sensation, the heterogeneous parts serving for the active functions. Again, as the sensory faculty, the motor faculty, and the nutritive faculty are all lodged in one and the same part of the body, as was stated in a former treatise,[2] it is necessary that the part which is the primary seat of these principles shall on the one hand, in its character of general sensory recipient, be one of the simple parts; and on the other hand shall, in its motor and active character, be one of the heterogeneous parts. For this reason it is the heart which in sanguineous animals constitutes this central part, and in bloodless animals it is that which takes the place of a heart. For the heart, like the other viscera, is one of the homogeneous parts; for, if cut up, its pieces are homogeneous in substance with each other. But it is at the same time heterogeneous in virtue of its definite configuration. And the same is true of the other so-called viscera, which are indeed formed from the
647b same material as the heart. For all these viscera have a sanguineous character owing to their being situated upon vascular ducts and branches. For just as a stream of water deposits mud, so the various viscera, the heart excepted,[3] are, as it were, deposits from the stream of blood in the vessels. And as to the heart, the very starting-point of the vessels, and the actual seat of the force by

[1] Cf. ii. 8. 653b 30 note.
[2] Cf. *De Somno*, 2. 455b 34, 456a 5.
[3] The heart is excepted, because A. thought that it was formed earlier than the blood, which is true if by blood be meant a red fluid.

which the blood is first fabricated, it is but what one would naturally expect, that out of the selfsame nutriment of which it is the recipient its own proper substance shall be formed. Such, then, are the reasons why the viscera are of sanguineous aspect; and why in one point of view they are homogeneous, in another heterogeneous.

2 Of the homogeneous parts of animals, some are soft and fluid, others hard and solid; and of the former some are fluid permanently, others only so long as they are in the living body.[1] Such are blood, serum, lard, suet, marrow, semen, bile, milk when present, flesh,[2] and their various analogues. For the parts enumerated are not to be found in all animals, some animals only having parts analogous to them. Of the hard and solid homogeneous parts bone, fish-spine, sinew, blood-vessel, are examples. The last of these points to a sub-division that may be made in the class of homogeneous parts. For in some [3] of them the whole and a portion of the whole in one sense are designated by the same term—as, for example, is the case with blood-vessel and bit of blood-vessel—while in another sense they are not; but a portion of a heterogeneous part, such as face, in no sense has the same designation as the whole.

The first question to be asked is what are the causes to which these homogeneous parts owe their existence? The causes are various; and this whether the parts be solid or fluid. Thus one set of homogeneous parts represent the material out of which the heterogeneous parts are formed; for each separate organ is constructed of bones, sinews, flesh, and the like; which are either essential elements in its formation, or contribute to the proper discharge of its function. A second set are the nutriment of the first, and are invariably fluid, for all growth occurs at the expense of

[1] Or 'the system'. For φύσις in this sense cf. ii. 3. 649^{b} 28–32.

[2] Flesh is presumably called fluid as being potentially blood (iii. 5. 668^{a} 27); a view which very possibly derived support from its cadaveric rigidity.

[3] Namely the simple organs. Cf. ii. 1. 646^{a} 21 note. Blood-vessel and bit of blood-vessel are both vascular tissue, but a bit of blood-vessel is not a blood-vessel.

fluid matter; while a third set are the residue of the second. Such, for instance, are the faeces and, in animals that have a bladder, the urine; the former being the dregs of the solid nutriment, the latter of the fluid.

Even the individual homogeneous parts present variations, which are intended in each case to render them more serviceable for their purpose. The variations of the blood may be selected to illustrate this. For different bloods differ in their degrees of thinness or thickness, of clearness or turbidity, of coldness or heat; and this whether we compare the bloods from different parts of the same individual or the bloods of different animals. For, in the individual, all the differences just enumerated distinguish the blood of
648a the upper and of the lower halves of the body; and, dealing with classes, one section of animals is sanguineous, while the other has no blood, but only something resembling it in its place. As regards the results of such differences, the thicker and the hotter blood is, the more conducive is it to strength, while in proportion to its thinness and its coldness is its suitability for sensation and intelligence. A like distinction exists also in the fluid which is analogous[1] to blood. This explains how it is that bees and other similar creatures are of a more intelligent nature than many sanguineous animals; and that, of sanguineous animals, those are the most intelligent whose blood is thin and cold. Noblest of all are those whose blood is hot, and at the same time thin and clear. For such are suited alike for the development of courage and of intelligence. Accordingly, the upper parts are superior in these respects to the lower, the male superior to the female, and the right side to the left.[2] As with the blood so also with the other parts,

[1] Reading *τὸ ἀνάλογον ὑπάρχον*.

[2] It was the unquestioning belief of Aristotle that the right was in nature superior to the left, the upper to the lower, the front to the back. He also held that 'Nature, when no more important purpose stands in the way, places the more honourable part in the more honourable position' (iii. 4. 665b 20). This dogma he uses as an axiom beyond dispute, and has recourse to it on numerous occasions in explanation of the relative positions of organs and other phenomena. The stomach, for instance, is placed where it is and not nearer the mouth because otherwise it would be above the heart, a nobler organ than itself (iv. 10. 686a 13). Man's nobility is shown by his upper part

homogeneous and heterogeneous alike. For here also such variations as occur must be held either to be related to the essential constitution and mode of life of the several animals, or, in other cases, to be merely matters of slightly better or slightly worse. Two animals, for instance, may have eyes. But in one these eyes may be of fluid consistency, while in the other they are hard; and in one there may be eyelids, in the other no such appendages. In such a case, the fluid consistency and the presence of eyelids, which are intended to add to the accuracy of vision, are differences of degree.

As to why all animals must of necessity have blood or something of a similar character, and what the nature of blood may be, these are matters which can only be considered when we have first discussed hot and cold. For the natural properties of many substances are referable to these two elementary principles; and it is a matter of frequent dispute what animals or what parts of animals are hot and what cold. For some[1] maintain that water animals are hotter than such as live on land, asserting that their natural heat counterbalances the coldness of their medium; and again, that bloodless animals are hotter than those with blood, and females than males. Parmenides, for instance, and some others declare that women are hotter than men, and that it is the warmth and abundance of their blood which causes their menstrual flow, while Empedocles maintains the opposite opinion. Again, comparing the blood and the bile, some speak of the former as hot and of the latter as cold, while others invert the description. If there be this endless disputing about hot and cold, which of all things that affect our senses are the most distinct, what are we to think as to our other sensory impressions?

The explanation of the difficulty appears to be that the term 'hotter' is used in several senses; so that different 648b

being turned towards the upper part of the universe (ii. 10. 656a 11). The front of man is chosen in preference to the back, for the growth of hair (ii. 14. 658a 23). The nictitating membrane comes from the canthus in front, rather than the canthus on the side (ii. 13. 657b 22). The heart, being the noblest part, is in front and in the upper half of the body (iii. 4. 665b 18), and so on.

[1] Empedocles, cf. *De Resp.* 14.

statements, though in verbal contradiction with each other, may yet all be more or less true. There ought, then, to be some clear understanding as to the sense in which natural substances are to be termed hot or cold, solid or fluid. For it appears manifest that these are properties on which even life and death are largely dependent, and that they are moreover the causes of sleep and waking, of maturity and old age, of health and disease; while no similar influence belongs to roughness and smoothness, to heaviness and lightness, nor, in short, to any other such properties of matter. That this should be so is but in accordance with rational expectation. For hot and cold, solid and fluid, as was stated in a former treatise,[1] are the foundations of the physical elements.

Is then the term hot used in one sense or in many? To answer this we must ascertain what special effect is attributed to a hotter substance, and if there be several such, how many these may be. A body then is in one sense said to be hotter than another, if it impart a greater amount of heat to an object in contact with it. In a second sense, that is said to be hotter which causes the keener sensation when touched, and especially if the sensation be attended with pain. This criterion, however, would seem sometimes to be a false one; for occasionally it is the idiosyncrasy of the individual that causes the sensation to be painful. Again, of two things, that is the hotter which the more readily melts a fusible substance, or sets on fire an inflammable one. Again, of two masses of one and the same substance, the larger is said to have more heat than the smaller. Again, of two bodies, that is said to be the hotter which takes the longer time in cooling, as also we call that which is rapidly heated hotter than that which is long about it; as though the rapidity implied proximity and this again similarity of nature, while the want of rapidity implied distance and this again dissimilarity of nature. The term hotter is used then in all the various senses that have been mentioned, and perhaps in still more. Now it is impossible for one body to be hotter than another in all these different

[1] *De G. et C.* ii. 2–3, *Meteor.* iv.

fashions. Boiling water for instance, though it is more scalding than flame, yet has no power of burning or melting combustible or fusible matter, while flame has. So again this boiling water is hotter than a small fire, and yet gets cold more rapidly and completely. For in fact fire never becomes cold; whereas water invariably does so. Boiling water, again, is hotter to the touch than oil; yet it gets cold and solid more rapidly than this other fluid. Blood, again, is hotter to the touch than either water or oil, and yet coagulates before them. Iron, again, and stones and other similar bodies are longer in getting heated than water, but when once heated burn other substances with a much greater intensity. Another distinction is this. In some of the bodies which are called hot the heat is derived from without, while in others it belongs to the bodies themselves; and it 649a makes a most important difference whether the heat has the former or the latter origin. For to call that one of two bodies the hotter, which is possessed of heat, we may almost say, accidentally and not of its own essence, is very much the same thing as if, finding that some man in a fever was a musician, one were to say that musicians are hotter than healthy men. Of that which is hot *per se* and that which is hot *per accidens*, the former is the slower to cool, while not rarely the latter is the hotter to the touch. The former again is the more burning of the two—flame, for instance, as compared with boiling water—while the latter, as the boiling water, which is hot *per accidens*, is the more heating to the touch. From all this it is clear that it is no simple matter to decide which of two bodies is the hotter. For the first may be the hotter in one sense, the second the hotter in another. Indeed in some of these cases it is impossible to say simply even whether a thing is hot or not. For the actual substratum may not itself be hot, but may be hot when coupled with heat as an attribute, as would be the case if one attached a single name to hot water or hot iron. It is after this manner that blood is hot.[1] In such cases, in those, that is, in which the substratum owes its heat to an external

[1] Because in A.'s opinion it derives its heat from the heart, or from the celestial heat which has its main seat in the heart.

influence, it is plain that cold is not a mere privation, but an actual existence.

There is no knowing but that even fire may be another of these cases. For the substratum of fire may be smoke or charcoal, and though the former of these is always hot, smoke being an uprising vapour, yet the latter becomes cold when its flame is extinguished, as also would oil and pinewood under similar circumstances. But even substances that have been burnt nearly all possess some heat, cinders, for example, and ashes, the dejections also of animals, and, among the excretions, bile; because some residue of heat has been left in them after their combustion. It is in another sense that pinewood and fat substances are hot; namely, because they rapidly assume the actuality of fire.

Heat appears to cause both coagulation and melting. Now such things as are formed merely of water are solidified by cold, while such as are formed of nothing but earth are solidified by fire. Hot substances again are solidified by cold, and, when they consist chiefly of earth, the process of solidification is rapid, and the resulting substance is insoluble; but, when their main constituent is water, the solid matter is again soluble. What kinds of substances, however, admit of being solidified, and what are the causes of solidification, are questions that have already been dealt with more precisely in another treatise.[1]

In conclusion, then, seeing that the terms hot and hotter
649b are used in many different senses, and that no one substance can be hotter than others in all these senses, we must, when we attribute this character to an object, add such further statements as that this substance is hotter *per se*, though that other is often hotter *per accidens*; or again, that this substance is potentially hot, that other actually so; or again, that this substance is hotter in the sense of causing a greater feeling of heat when touched, while that other is hotter in the sense of producing flame and burning. The term hot being used in all these various senses, it plainly follows that the term cold will also be used with like ambiguity.

[1] Cf. *Meteor.* iv. 6–8, 10.

So much then as to the signification of the terms hot and cold, hotter and colder.

3 In natural sequence we have next to treat of solid and fluid. These terms are used in various senses. Sometimes, for instance, they denote things that are potentially, at other times things that are actually, solid or fluid. Ice for example, or any other solidified fluid, is spoken of as being actually and accidentally solid, while potentially and essentially it is fluid. Similarly earth and ashes and the like, when mixed with water, are actually and accidentally fluid, but potentially and essentially are solid. Now separate the constituents in such a mixture and you have on the one hand the watery components to which its fluidity was due,[1] and these are both actually and potentially fluid, and on the other hand the earthy components, and these are in every way[2] solid; and it is to bodies that are solid in this complete manner that the term 'solid' is most properly and absolutely applicable. So also the opposite term 'fluid' is strictly and absolutely applicable to that only which is both potentially and actually fluid. The same remark applies also to hot bodies and to cold.

These distinctions, then, being laid down, it is plain that blood is essentially hot in so far as that heat is connoted in its name; just as if boiling water were denoted by a single term, boiling would be connoted in that term. But the substratum of blood, that which it is in substance while it is blood in form, is not hot. Blood then in a certain sense is essentially hot, and in another sense is not so. For heat is included in the definition of blood, just as whiteness is included in the definition of a white man, and so far therefore blood is essentially hot. But so far as blood becomes hot from some external influence, it is not hot essentially.

[1] The distinctive character of a fluid is that it is ἀναπληστικόν, that is, that it has no shape of its own but takes that of the vessel which it fills up as a mould (*De G. et C.* ii. 2. 329b 34). To say then that a constituent of a mixture is ἀναπληστικόν is to say that it confers fluidity on the mixture.

[2] That is, 'both potentially and actually'. Ἅπαντα, if the true reading, must be taken as adverbial and as used though 'de duobus tantum agitur' (Bonitz, 571b 51); but I suggest πάντως as a preferable reading.

As with hot and cold, so also is it with solid and fluid. We can therefore understand how some substances are hot and fluid so long as they remain in the living body, but become perceptibly cold and coagulate so soon as they are separated from it; while others are hot and consistent while in the body, but when withdrawn undergo a change to the opposite condition, and become cold and fluid. Of the former blood is an example, of the latter bile; for while blood solidifies when thus separated, yellow bile under the same circumstances becomes more fluid. We must attribute to such substances the possession of opposite properties in a greater or less degree.

650a In what sense, then, the blood is hot and in what sense fluid, and how far it partakes of the opposite properties, has now been fairly explained. Now since everything that grows must take nourishment, and nutriment in all cases consists of fluid and solid substances, and since it is by the force of heat that these are concocted and changed, it follows that all living things, animals and plants alike, must on this account, if on no other, have a natural source of heat. This natural heat, moreover, must belong to many parts,[1] seeing that the organs by which the various elaborations of the food are effected are many in number. For first of all there is the mouth and the parts inside the mouth, on which the first share in the duty clearly devolves, in such animals at least as live on food which requires disintegration. The mouth, however, does not actually concoct the food, but merely facilitates concoction; for the subdivision of the food into small bits facilitates the action of heat upon it. After the mouth come the upper and the lower abdominal cavities,[2] and here it is that concoction is

[1] A. looked on the heart as the main but not the exclusive seat of vital heat. 'The whole body and all its parts have a certain connate natural heat. But in sanguineous animals the main seat of this heat must be the heart. For, though the other parts by their natural heat can effect the concoction of the food, yet chief and foremost in this office is the heart. The rest of the body then may become cold, and yet life continue; but should the heart cease to be hot, all life is at an end; for no longer does there remain a source whence the rest of the body may derive heat' (*De Iuv. et Sen.* 4. 469b 12).

[2] The upper cavity is of course the stomach. By the lower is meant

effected by the aid of natural heat. Again, just as there is a channel for the admission of the unconcocted food into the stomach, namely the mouth, and in some animals the so-called oesophagus, which is continuous with the mouth and reaches to the stomach, so must there also be other and more numerous channels by which the concocted food or nutriment shall pass out of the stomach and intestines into the body at large, and to which these cavities shall serve as a kind of manger. For plants get their food from the earth by means of their roots; and this food is already elaborated when taken in, which is the reason why plants produce no excrement,[1] the earth and its heat serving them in the stead of a stomach. But animals, with scarcely an exception, and conspicuously all such as are capable of locomotion, are provided with a stomachal sac, which is as it were an internal substitute for the earth. They must therefore have some instrument which shall correspond to the roots of plants, with which they may absorb their food from this sac, so that the proper end of the successive stages of concoction may at last be attained. The mouth then, its duty done, passes over the food to the

the large intestine, or rather its caecal enlargement. This is sometimes, as here, spoken of by A. as a seat of digestion, that is as a second stomach, and sometimes merely as a receptacle of residual matter, as though all digestion were over before this part was reached. We may fairly suppose that A. in the different passages is speaking of different animals; for while the caecum in some animals, as in the horse, really acts as a second stomach, in others, as in man, its contents are almost entirely faecal.

[1] Περίττωμα, like the nutriment (*G. A.* i. 18. 725^a 4) of which it is the surplus, is of two kinds, the useless (ἄχρηστον) and the serviceable (χρήσιμον). The former is eliminated, mainly by the bowels and kidneys, and may be called the excremental residue. The latter is such of the nutriment reduced to blood as remains after the nobler parts, such as the sense-organs and flesh, have taken what they require (*G. A.* ii. 6. 744^b 23). This surplus is utilized in various ways. Some is spent on the inert parts, such as nails, hairs, sinews, bones (744^b 25); some is stored up as fat (ii. 5. 651^a 21); and some forms useful secretions and notably the generative (iv. 10. 689^a 8–13). All these products of the περίττωμα are themselves called περιττώματα. The χρήσιμον περίττωμα in the blood contrasts with the σύντηγμα or product of body-waste (*G. A.* i. 18. 724^b 26 sq.); and when A. says of anything, other than excrement, that it is περίττωμα, he means that it derives from the serviceable residue, not from the effete matter. Plants, he says above, have no excremental residue, while their serviceable residue forms their fruit and seeds (ii. 10. 655^b 35).

stomach, and there must necessarily be something to receive it in turn from this. This something is furnished by the blood-vessels, which run throughout the whole extent of the mesentery from its lowest part right up to the stomach. A description of these will be found in the treatises on Anatomy and Natural History.[1] Now as there is a receptacle for the entire matter taken as food, and also a receptacle for its excremental residue, and again a third receptacle, namely the vessels, which serve as such for the blood, it is plain that this blood must be the final nutritive material in such animals as have it; while in bloodless animals the same is the case with the fluid which represents the blood. This explains why the blood diminishes in quantity when no food is taken, and increases
650b when much is consumed, and also why it becomes healthy and unhealthy according as the food is of the one or the other character. These facts, then, and others of a like kind, make it plain that the purpose of the blood in sanguineous animals is to subserve the nutrition of the body. They also explain why no more sensation is produced by touching the blood than by touching one of the excretions or the food, whereas when the flesh is touched sensation is produced. For the blood is not continuous nor united by growth with the flesh, but simply lies loose in its receptacle, that is in the heart and vessels. The manner in which the parts grow at the expense of the blood, and indeed the whole question of nutrition, will find a more suitable place for exposition in the treatise on Generation, and in other writings.[2] For our present purpose

[1] Cf. *H.A.* i. 16; iii. 4. 514^b 12.

[2] A. often refers to a treatise which he was going to write on Nutrition. It has been generally supposed that the *De Generatione Animalium*, in which (ii. 4. 740^a 21–^{b} 12, ii. 6. 743^a 8–7. 746^a 28) nutrition is handled to a certain extent, is the treatise thus promised. But this view seems incompatible with the fact that a similar reference to a future treatise 'on growth and nutrition' is made in the *De Generatione* itself (v. 4. 784^b 3). The present passage, moreover, speaks of 'other writings' besides the *De Generatione*. The promised treatise is not extant; perhaps was never written; for no mention of such is to be found in Diogenes Laertius. Heitz (*Die verlor. Schrift. d. Arist.* 61) thinks it probable that a short separate treatise was written, such as those massed together in the *Parva Naturalia*, and that some portions of it have come down to us merged in the *De Generatione*;

all that need be said is that the blood exists for the sake of nutrition, that is the nutrition of the parts; and with this much let us therefore content ourselves.

4 What are called fibres are found in the blood of some animals but not of all. There are none, for instance, in the blood of deer and of roes;[1] and for this reason the blood of such animals as these never coagulates. For one part of the blood consists mainly of water[2] and therefore does not coagulate, this process occurring only in the other and earthy constituent, that is to say in the fibres, while the fluid part is evaporating.

Some at any rate of the animals with watery blood have a keener intellect than those whose blood is of an earthier nature. This is due not to the coldness of their blood, but rather to its thinness and purity; neither of which qualities belongs to the earthy matter. For the thinner and purer its fluid is, the more easily affected is an animal's sensibility. Thus it is that some bloodless animals, notwithstanding their want of blood, are yet more intelligent than some among the sanguineous kinds. Such for instance, as already said,[3] is the case with the bee and the tribe of ants, and whatever other animals there may be of a like nature. At the same time too great an excess of water makes animals timorous. For fear chills the body; so that in animals whose heart contains so watery a mixture the way is prepared for the operation of this emotion. For water is congealed by cold. This also explains why bloodless animals are, as a general rule, more timorous than such as have blood, so that they remain motionless, when frightened, and discharge their excretions, and in some

and there is in fact in the *De Somno* (3. 456^b 6) a passage which apparently refers to a treatise on Nutrition as already written. The subject is treated in *De G. et C.* i. 5. 321^a 32 – 322^a 33, ii. 8. 335^a 10, *Meteor.* iv. 2. 379^b 23.

[1] Elsewhere (*H. A.* iii. 6. 515^b 34) to these animals are added the Bubalis (antelope) and hare. It will be noted that all these are animals that are hunted: and the blood of animals hunted to death coagulates so imperfectly that J. Hunter was led to suppose erroneously that it did not coagulate at all (Hunter's *Works*, i. 234). A. (*H. A.* iii. 6. 516^a 1) admits an imperfect coagulation of such blood.

[2] Omitting ψυχρόν (Z).

[3] Cf. ii. 2. 648^a 6.

instances change colour.[1] Such animals, on the other hand, as have thick and abundant fibres in their blood are of a more earthy nature, and of a choleric temperament, and liable to bursts of passion. For anger is productive of heat; and solids, when they have been made hot, give off more heat 651a than fluids. The fibres therefore, being earthy and solid, are turned into so many hot embers in the blood, like the embers in a vapour-bath, and cause ebullition in the fits of passion.

This explains why bulls and boars are so choleric and so passionate. For their blood is exceedingly rich in fibres,[2] and the bull's at any rate coagulates more rapidly than that of any other animal.[3] If these fibres, that is to say if the earthy constituents of which we are speaking, are taken out of the blood, the fluid that remains behind will no longer coagulate; just as the watery residue of mud will not coagulate after removal of the earth. But if the fibres are left the fluid coagulates, as also does mud, under the influence of cold. For when the heat is expelled by the cold, the fluid, as has been already stated, passes off with it by evaporation, and the residue is dried up and solidified, not by heat but by cold.[4] So long, however, as the blood is in the body, it is kept fluid by animal heat.

[1] The bloodless animals that remain motionless when frightened are beetles, moths, &c. (iv. 6. 682b 25). Those that discharge their excreta are various insects and cephalopods (iv. 5. 679a 6); and it is these latter that change colour (iv. 5. 679a 13).

[2] Elsewhere (*H. A.* iii. 19. 521a 5) the ass is instanced as well as the bull. Bovine animals (but still more swine and horses) have a larger proportion of fibrine in their blood than men (Andral, *Ann. de Chimie*, 1842, p. 306); and from such scanty observations as exist it would seem that the blood of bulls is richer in fibrine than that of cows or oxen (*ibid.* p. 307). Thackrah seems to have arrived at much the same general conclusion as Aristotle. 'Although my experiments are far from evincing a disparity uniform in its reference to the classes of animals, yet it appears probable that a more complete examination would prove *the crassamentum to bear a proportion to the strength and ferocity of the animal*, since I never found the serum in such quantity as in the timid sheep, nor the crassamentum so abundant as in the predatory dog' (*On the Blood*, 1834, p. 154).

[3] Thackrah says (*On the Blood*, p. 154) that 'from my observations the general inference may be drawn that coagulation commences sooner in small and weak animals than in large and strong'. This seems in contradiction with A.'s statement.

[4] Cf. *Meteor.* iv. 6-8, where A. discusses at length the questions of coagulation, liquefaction, &c.

The character of the blood affects both the temperament and the sensory faculties of animals in many ways. This is indeed what might reasonably be expected, seeing that the blood is the material of which the whole body is made. For nutriment supplies the material, and the blood is the ultimate nutriment. It makes then a considerable difference whether the blood be hot or cold, thin or thick, turbid or clear.

The watery part of the blood is serum ; and it is watery, either owing to its not being yet concocted, or owing to its having become corrupted ; so that one part of the serum is the resultant of a necessary process,[1] while another part is material intended to serve for the formation of the blood.

5 The differences between lard and suet correspond to differences of blood.[2] For both are blood concocted into these forms as a result[3] of abundant nutrition, being that surplus blood that is not expended on the fleshy part of the body, and is of an easily concocted and fatty character. This is shown by the unctuous aspect of these substances ; for such unctuous aspect in fluids is due to a combination of air and fire.[4] It follows from what has been said that no non-sanguineous animals have either lard or suet ; for they have no blood. Among sanguineous animals those whose blood

[1] By the 'necessary process' is meant the waste of the body (σύντηξις) that is constantly going on, but is increased by toil (*De Somno*, 3. 456^{b} 34). The effete matter (σύντηγμα) that results from this necessary process, passing into the blood on its way to elimination by the various emunctories, is there commingled with nutritive material (χρήσιμον περίττωμα) that is on its way to repair the body-waste. This σύντηγμα, to use modern terms, is catabolic matter, while the χρήσιμον περίττωμα is anabolic.

[2] A. calls the softer kinds of fat πιμελή and the harder kinds στέαρ, terms corresponding to the Pinguedo and Sevum of later times. These are here rendered Lard and Suet, 'lard' being used in want of a better word for any soft fat, not merely that of swine. J. Hunter made four divisions—Oil, Lard, Tallow, Spermaceti, also taking consistency as the basis of distinction.

[3] A. held that in over-fed or well-fed animals the blood was of such a character as favoured its conversion by further concoction into fat rather than into generative secretions ; just as vines in rich soil run to leaf rather than to fruit. *G. A.* i. 18. 725^{b} 26 sq., ii. 7. 746^{b} 27 ; *H. A.* v. 14. 546^{a} 1.

[4] This clause seems so inconsecutive that one may suspect it to be an interpolation.

is dense have suet rather than lard. For suet is of an earthy nature, that is to say, it contains but a small proportion of water and is chiefly composed of earth; and this it is that makes it coagulate, just as the fibrous matter of blood coagulates, or broths which contain such fibrous matter. Thus it is that in those horned animals that have no front teeth in the upper jaw the fat consists of suet. For the very fact that they have horns and huckle-bones [1] shows that their composition is rich in this earthy element; for all such appurtenances are solid and earthy in character. On the other hand in those hornless animals that have front teeth in both jaws, and whose feet are divided into toes, there is no suet, but in its place lard; [2] and this, not being of an earthy character, neither coagulates nor dries up into a friable mass.

Both lard and suet when present in moderate amount are beneficial; for they contribute to health and strength, while 651b they are no hindrance to sensation. But when they are present in great excess, they are injurious and destructive. For were the whole body formed of them it would perish. For an animal is an animal in virtue of its sensory part, that is in virtue of its flesh, or of the substance analogous to flesh.[3] But the blood, as before stated, is not sensitive; as therefore is neither lard nor suet, seeing that they are nothing but concocted blood. Were then the whole body composed of these substances, it would be utterly without sensation. Such animals, again, as are excessively fat age rapidly. For so much of their blood is used in forming fat, that they have but little left; and when there is but little blood the way is already open for decay.[4] For decay may be said to be deficiency of blood, the scantiness of which renders it

[1] Cf. iv. 10. 690a 13 note.

[2] i.e. Swine. Elsewhere (*H. A.* iii. 17. 520a 9) A. says correctly that the horse as well as the hog has soft fat.

[3] Cf. ii. 8. 653b 30 note.

[4] Cf. Thackrah, *On the Blood*, p. 131: 'Fat animals have I believe considerably less blood in proportion to their weight than lean ones; and in the fat human subject venesection shows the veins to be comparatively small, and the quantity of blood, even when two or three vessels are opened, is less than flows from one vein of a lean person' etc.

liable, like all bodies of small bulk, to be injuriously affected by any chance excess of heat or cold. For the same reason fat animals are less prolific than others. For that part of the blood which should go to form semen and seed is used up in the production of lard and suet, which are nothing but concocted blood; so that in these animals there is either no reproductive excretion at all, or only a scanty amount.[1]

6 So much then of blood and serum, and of lard and suet. Each of these has been described, and the purposes told for which they severally exist.

The marrow also is of the nature of blood, and not, as some [2] think, the germinal force of the semen. That this is the case is quite evident in very young animals. For in the embryo the marrow of the bones has a blood-like appearance, which is but natural, seeing that the parts are all constructed out of blood, and that it is on blood that the embryo is nourished.[3] But, as the young animal grows up and ripens into maturity, the marrow changes its colour, just as do the external parts and the viscera.[4] For the viscera also in animals, so long as they are young, have each and all a blood-like look, owing to the large amount of this fluid which they contain.

The consistency of the marrow agrees with that of the fat. For when the fat consists of lard, then the marrow also is unctuous and lard-like; but when the blood is converted by concoction into suet, and does not assume the form [5] of lard, then the marrow also has a suety character.

[1] 'On dirait qu'il y a un rapport constant et rigoureux entre la sécrétion de la semence et l'exhalation de la graisse; que ces deux fluides sont en raison inverse l'un de l'autre' (Bichat, *Anat. Gén.* i. 55). That over-fat animals are bad breeders is known to every farmer. So also it is well known that castrated animals grow fat.

[2] Alluding to Plato, who expresses this view in the *Timaeus* (73 c).

[3] 'The bones of the foetus are void of a distinct medullary canal, and present merely a reddish homogeneous vascular pulp, somewhat consistent but presenting soft portions. This state continues for some time after birth' (Todd, *Cyclop. Anat. and Phys.* i. 60). So also Virchow's *Cellularpath.* 369.

[4] In the foetus and infant there is less pigment in the body generally than in the adult. The skin, hair, eyes (*G.A.* v. 1. 779^{a} 26), and olfactory region, are all lighter-coloured than in later life.

[5] For ὅμοιος read ὅμοιον (Z).

In those animals, therefore, that have horns and are without upper front teeth, the marrow has the character of suet; while it takes the form of lard in those that have front teeth in both jaws, and that also have the foot divided into toes. What has been said hardly applies to the spinal marrow. For it is necessary that this shall be continuous and extend without break through the whole backbone, inasmuch as this bone consists of separate vertebrae. But were the spinal marrow[1] either of unctuous fat or of suet, it could not hold together in such a continuous mass as it does, but would either be too fluid or too frangible.

There are some animals that can hardly be said to have any marrow. These are those whose bones are strong and
652a solid, as is the case with the lion. For in this animal the marrow is so utterly insignificant that the bones look as though they had none at all. However, as it is necessary that animals shall have bones or something analogous to them, such as the fish-spines of water-animals, it is also a matter of necessity that some of these bones shall contain marrow; for the substance contained within the bones is the nutriment out of which these are formed. Now the universal nutriment, as already stated,[2] is blood; and the blood within the bone, owing to the heat which is developed in it from its being thus surrounded, undergoes concoction, and self-concocted[3] blood is suet or lard; so that it is perfectly intelligible how the marrow within the bone comes to have the character of these substances. So also it is easy to understand why, in those animals that have strong and compact bones, some of these should

[1] That the spinal cord is the marrow of the vertebrae is an error, the memory of which is still preserved in the popular term 'spinal marrow'.

[2] Cf. ii. 4. 651a 14.

[3] This passage is of importance; for it indicates the answer to the obvious objection, that many of the phenomena attributed by A. to heat are manifestly not so producible. For, in using the term 'self-concoction', A. means to draw a distinction between ordinary heat and the heat of the blood or body. Mere cooking with fire of course does not convert blood into fat, nor digest food, nor the like. But the heat of the body, as the heat of the sun, says A. (*G. A.* ii. 3. 737a 1), is something very different from this. It has a vivifying influence, which simple fire has not, and produces effects far beyond the power of this element.

be entirely void of marrow, while the rest contain but little of it;[1] for here the nutriment is spent in forming the bones.

Those animals that have fish-spines in place of bones have no other marrow than that of the chine.[2] For in the first place they have naturally but a small amount of blood; and secondly the only hollow fish-spine is that of the chine. In this then marrow is formed; this being the only spine in which there is space for it, and, moreover, being the only one which owing to its division into parts requires a connecting bond. This too is the reason why the marrow of the chine, as already mentioned, is somewhat different from that of other bones. For, having to act the part of a clasp, it must be of glutinous character, and at the same time sinewy so as to admit of stretching.

Such then are the reasons for the existence of marrow, in those animals that have any, and such its nature. It is evidently the surplus of the sanguineous nutriment apportioned to the bones and fish-spines, which has undergone concoction owing to its being enclosed within them.

7 From the marrow we pass on in natural sequence to the brain. For there are many[3] who think that the brain itself consists of marrow, and that it forms the commencement of that substance, because they see that the spinal marrow is continuous with it. In reality the two may be said to be utterly opposite to each other in character. For of all the parts of the body there is none so cold as the brain; whereas the marrow is of a hot nature, as is plainly shown by its fat and unctuous character. Indeed this is the very reason why the brain and spinal marrow are continuous with each other. For, wherever the action of any part is in excess, nature so contrives as to set by it another part with an excess of contrary action, so that the excesses of the two may counterbalance each other. Now that the marrow is hot is clearly shown by many indications. The

[1] Reading ὀλίγος for ὀλίγοις (U).

[2] No fish has a medullary canal in its bones, though there are some, as the trout, in which the bony tissue is more or less penetrated by an oily fluid (Todd, *Cyclop. of An. and Phy.* iii. 958).

[3] As Plato in the *Timaeus* (73 c).

coldness of the brain is also manifest enough.[1] For in the first place it is cold even to the touch; and, secondly, of all the fluid parts of the body it is the driest[2] and the one that has the least blood; for in fact it has no blood
652b at all in its proper substance. This brain is not residual matter, nor yet is it one of the parts which are anatomically continuous[3] with each other; but it has a character peculiar to itself, as might indeed be expected. That it has no continuity with the organs of sense is plain from simple inspection, and is still more clearly shown by the fact, that, when it is touched, no sensation is produced; in which respect it resembles the blood of animals and their excrement. The purpose of its presence in animals is no less than the preservation of the whole body. For some[4] writers assert that the soul is fire or some such force. This, however, is but a rough and inaccurate assertion; and it would perhaps be better to say that the soul is incorporate in some substance of a fiery character. The reason for this being so is that of all substances there is none so suitable for ministering to the operations of the soul as that which is possessed of heat. For nutrition and the imparting of motion are offices of the soul, and it is by heat that

[1] There are three strange statements in this chapter as to the brain—that it is cold; that it is bloodless; that it is fluid. (α) The belief that the brain is cold lasted from the time of Hippocrates into the sixteenth or even the seventeenth century. For, as Dr. Payne states in his Harveian Oration, it was taught by Harvey in his MS. Praelectiones of 1616, and this though an anatomist of the preceding century is quoted by himself as having placed one hand on the heart and the other on the brain of a recently killed animal and found them equally hot. (β) Most of the blood that goes to the brain goes to the superficial gray matter. This, differing as it does from the mass below in colour and general aspect, was considered by A. to be part of the highly vascular *Pia mater*, from which indeed he can hardly have learnt to separate it mechanically. He appears to have overlooked the small vessels which penetrate the white mass, and which, though numerous, only appear as bloody puncta. (γ) A. uses the term 'fluid' with much latitude; and may mean no more than that the brain is, as Galen calls it, 'nearly fluid.' At any rate he qualifies his statement very much by saying that of all the fluids it is the least fluid (αὐχμηρότατον), that is, the most consistent, and that it is only fluid in the young and becomes consolidated afterwards (*G. A.* ii. 6. 744a 17).

[2] i. e. the most consistent.

[3] Such as the vascular or osseous systems. See ii. 9. 654a 33.

[4] Democritus (*De An.* i. 2. 403b 31).

these are most readily effected. To say then that the soul is fire is much the same thing as to confound the auger or the saw with the carpenter or his craft, simply because the work is wrought by the two in conjunction. So far then this much is plain, that all animals must necessarily have a certain amount of heat. But as all influences require to be counterbalanced, so that they may be reduced to moderation and brought to the mean (for in the mean, and not in either extreme, lies the true and rational position), nature has contrived the brain as a counterpoise to the region of the heart with its contained heat, and has given it to animals to moderate the latter, combining in it the properties of earth and water.[1] For this reason it is, that every sanguineous animal has a brain; whereas no bloodless creature has such an organ, unless indeed it be, as the Poulp, by analogy.[2] For where there is no blood, there in consequence there is but little heat. The brain, then, tempers the heat and seething of the heart. In order, however, that it may not itself be absolutely without heat, but may have a moderate amount, branches run from both blood-vessels,[3] that is to say from the great vessel and from what is called the aorta, and end in the membrane which surrounds the brain;[4] while at the same time, in order to prevent any injury from the heat, these encompassing vessels, instead of being few and large, are numerous and small, and their blood scanty and clear, instead of being abundant and thick. We can now understand why defluxions have their origin in the head, and occur whenever the parts about the brain have more than a due propor-

[1] And therefore causing it to be cold; for both earth and water are compounds of cold matter, the former with solid, the latter with fluid matter. (Cf. ii. 1. 646a 16 note.)

[2] Elsewhere (*H. A.* i. 16. 494b 27) A. speaks of Cephalopods in general, and not only of the Poulp, as having a brain. The cephalic ganglia in these animals are so large as to rival the brains of vertebrates in size and importance.

[3] Cf. iii. 5. 667b 16 note.

[4] i. e. the *pia mater*. A. (*H. A.* i. 16) describes the brain as having two membranes, an outer and stronger one next to the bone (*dura mater*), and an inner one in contact with the brain itself (*pia mater*). This latter is the vascular one, so often mentioned by Aristotle. This membrane consists in great part of a plexus of extremely numerous and very minute vessels, as A. says.

tion of coldness. For when the nutriment steams upwards 653a through the blood-vessels, its refuse portion is chilled by the influence of this region, and forms defluxions of phlegm and serum. We must suppose, to compare small things with great, that the like happens here as occurs in the production of showers. For when vapour steams up from the earth and is carried by the heat into the upper regions, so soon as it reaches the cold air that is above the earth, it condenses again into water owing to the refrigeration, and falls back to the earth as rain. These, however, are matters which may be suitably considered in the Principles of Diseases,[1] so far as natural philosophy has anything to say to them.

It is the brain again—or, in animals that have no brain, the part analogous to it—which is the cause of sleep. For either by chilling the blood that streams upwards after food, or by some other similar influences, it produces heaviness in the region in which it lies (which is the reason why drowsy persons hang the head), and causes the heat to escape downwards in company with the blood. It is the accumulation of this in excess in the lower region that produces complete sleep, taking away the power of standing upright from those animals to whom that posture is natural, and from the rest the power of holding up the head. These, however, are matters which have been separately considered in the treatises on Sensation and on Sleep.[2]

That the brain is a compound of earth and water is shown by what occurs when it is boiled. For, when so treated, it turns hard and solid, inasmuch as the water is evaporated by the heat, and leaves the earthy part behind. Just the same occurs when pulse and other fruits are boiled. For these also are hardened by the process, because the water which enters into their composition is driven off and leaves the earth, which is their main constituent, behind.

Of all animals, man has the largest brain in proportion to

[1] As to the question whether the promised treatise on the Principles of Diseases was ever written, see Heitz, *Die verlor. Schrift. d. Arist.* p. 58.

[2] *De Somno*, 2. 455^b 28 – 3. 458^a 32. I find nothing in *De Sensu.*

his size; and it is larger in men than in women. This is because the region of the heart and of the lung is hotter and richer in blood in man than in any other animal; and in men than in women. This again explains why man, alone of animals, stands erect. For the heat, overcoming any opposite inclination, makes growth take its own line of direction, which is from the centre of the body upwards. It is then as a counterpoise to his excessive heat that in man's brain there is this superabundant fluidity and coldness; and it is again owing to this superabundance that the cranial bone, which some call the Bregma,[1] is the last to become solidified; so long does evaporation[2] continue to occur through it under the influence of heat. Man is the only sanguineous animal in which this takes place. Man, again, has more sutures in his skull than any 653b
other animal,[3] and the male more than the female.[4] The explanation is again to be found in the greater size of the brain, which demands free ventilation, proportionate to its bulk. For if the brain be either too fluid or too solid, it will not perform its office, but in the one case will freeze the blood, and in the other will not cool it at all; and thus will cause disease, madness, and death. For the cardiac heat and the centre of life is most delicate in its sympathies, and is immediately sensitive to the slightest change or affection of the blood on the outer surface of the brain.[5]

[1] i. e. the anterior fontanel, considered by A. to be a separate bone (*H. A.* i. 7. 491a 31).

[2] The erroneous notion that the use of the sutures is to ventilate the brain is repeated by Galen (*De Inst. Odor.* 2; *De Sanit. tuenda*, i. 13).

[3] This is an error. A. was probably led to it by the fact that in numerous animals the sutures become more or less effaced at a very early age. This is notably the case with birds, fishes, and, of mammals, with the cetacea and elephants.

[4] The sutures in the female skull are really identical with those of the male. Still it is not impossible that A.'s statement may have been founded on some single observation. For it is by no means uncommon for the sutures on the vertex to become more or less effaced in pregnant women; so common indeed is it, that the name 'puerperal osteophyte' has been given to the condition by Rokitansky (*Path. Anat.* iii. 208, Syd. Soc. Transl.).

[5] A. is ridiculed by Galen for having made the brain no more than a spongeful of cold water. It is plain, however, that in reality he assigned to it an office scarcely less important than that he attached to the heart. It is true he made this latter the actual sensory centre,

The fluids which are present in the animal body at the time of birth have now nearly all been considered. Amongst those that appear only at a later period are the residua of the food, which include the deposits of the belly and also those of the bladder. Besides these there is the semen and the milk, one or the other of which makes its appearance in appropriate animals. Of these fluids, the excremental residua of the food may be suitably discussed by themselves, when we come to examine and consider the subject of nutrition. Then will be the proper time to explain in what animals they are found, and what are the reasons for their presence. Similarly all questions concerning the semen and the milk may be dealt with in the treatise on Generation,[1] for the former of these fluids is the very starting-point of the generative process, and the latter has no other ground of existence than generative purposes.

We have now to consider the remaining homogeneous 8
parts, and will begin with flesh, and with the substance that, in animals that have no flesh, takes its place. The reason for so beginning is that flesh forms the very basis of animals, and is the essential constituent of their body. Its right to this precedence can also be demonstrated logically. For an animal is by our definition something that has sensibility and chief of all the primary sensibility, which is that of Touch;[2] and it is the flesh, or analogous substance, which is the organ of this sense. And it is the organ, either in the same way as the pupil is the organ of sight, that is it constitutes the primary organ of the sense; or it is the organ and the medium through which the object acts com-

but he represented it as so directly dependent upon the brain for the discharge of its functions, and as so instantaneously affected by any change which occurs in this organ, that heart and brain came as it were to form one consolidated organ.

[1] *G. A.* i. 17 – ii. 3, iv. 8.

[2] Not meaning that the other special senses are only modifications of touch or general sensibility. For this view, entertained by Democritus, is expressly repudiated by A. (*De Sensu*, 4. 442^a 29). Touch is to A. the primary sense, firstly because it is the most universally distributed of the senses; no animals being without it, though they may be without any other (*De An.* iii. 13. 435^b 1; ii. 3. 415^a 3; *H. A.* i. 3. 489^a 17); and secondly, because it is by touch that we are able to recognize the four primary properties of matter (*De An.* ii. 11).

bined, that is it answers to the pupil with the whole transparent medium attached to it. Now in the case of the other senses it was impossible for nature to unite the medium with the sense-organ, nor would such a junction have served any purpose; but in the case of touch she was compelled by necessity to do so. For of all the sense-organs that of touch is the only one that has corporeal substance, or at any rate it is more corporeal than any other, and its medium must be corporeal like itself.[1]

It is obvious also to sense[2] that it is for the sake of the flesh that all the other parts exist. By the other parts I mean the bones, the skin, the sinews, and the blood-vessels, and, again, the hair and the various kinds of nails, and anything else there may be of a like character. Thus the bones are a contrivance to give security to the soft parts,[3] to which purpose they are adapted by their hardness; and in animals that have no bones the same office is fulfilled by some analogous substance, as by fish-spine in some fishes, and by cartilage in others.

Now in some animals this supporting substance is situated
within the body, while in some of the bloodless species it is 654a

[1] A.'s statements as to the relation of the flesh to Touch are by no means clear. The flesh is sometimes (ii. 1. 651a 20) spoken of as the Sense-organ (αἰσθητήριον) of Touch; sometimes this is strenuously denied (ii. 10. 656b 25) and it is said to be the medium (τὸ μεταξὺ τοῦ ἁπτικοῦ). Here it is suggested that it is medium and organ combined; and this seems to be the view to which A. inclines, the outer mass of flesh being the medium and some undefined and purely hypothetical part of it, situated internally in close proximity to the heart (ἔνδον, πρὸς τῇ καρδίᾳ), being the organ. Medium, organ, and heart being thus in continuity with each other, any motion of the medium affects organ and heart not in succession but simultaneously, just as a blow on a shield in immediate contact with the body affects shield and body together. A. held (*De G. et C.* i. 7) that nothing could be set in motion except by an agent generically homogeneous with itself. In sensation the object of sense sets the medium in motion, and then the motion of the medium is communicated to the sense-organ (*De An.* ii. 7). The medium then and the sense-organ must be generically alike. Now, wherever an animal may be, its eye and ear find media of corresponding nature to themselves in the external air or water; but the sense-organ of Touch being a corporeal, that is a solid, substance requires a solid medium, and this it can only have if attached to itself and carried about as part of the body.

[2] Besides having its right to precedence logically demonstrable, as stated a few sentences back.

[3] Reading τοῦ μαλακοῦ.

placed on the outside. The latter is the case in all the Crustacea,[1] as the Carcini (*Crabs*) and the Carabi (*Prickly Lobsters*); it is the case also in the Testacea, as for instance in the several species known by the general name of oysters. For in all these animals the fleshy substance is within, and the earthy matter, which holds the soft parts together and keeps them from injury, is on the outside. For the shell not only enables the soft parts to hold together, but also, as the animal is bloodless and so has but little natural warmth, surrounds it, as a chaufferette does the embers, and keeps in the smouldering heat. Similar to this seems to be the arrangement in another and distinct tribe of animals, namely the Tortoises, including the Chelone and the several kinds of Emys.[2] But in Insects and in Cephalopods the plan is entirely different, there being moreover a contrast between these two themselves. For in neither of these does there appear to be any bony or earthy part, worthy of notice, distinctly separated from the rest of the body. Thus in the Cephalopods the main bulk of the body consists of a soft flesh-like substance, or rather of a substance which is intermediate to flesh and sinew, so as not to be so readily destructible as actual flesh. I call this substance intermediate to flesh and sinew, because it is soft like the former, while it admits of stretching like the latter.[3] Its cleavage, however, is such that it splits not longitudinally, like sinew, but into circular segments, this being the most advantageous condition, so far as strength is concerned. These animals have also a part inside them corresponding to the spinous bones of fishes. For instance, in the Cuttle-fishes there is what is known as the *os sepiae*, and in the Calamaries there is the so-called *gladius*. In the Poulps,[4] on the other hand, there is no such internal part, because the body, or, as it is termed in them, the head,[5] forms but a short sac, whereas it is of considerable length in the other two; and it was this length which led

[1] Cf. iv. 8. 683ᵇ 25 note.
[2] Cf. iii. 9. 671ª 32 note.
[3] Cf. iii. 4. 666ᵇ 13 note.
[4] Read *τό* for *τά* and *γένος* after *πολυπόδων* (Platt).
[5] Cf. iv. 9. 685ª 5 note.

nature to assign to them their hard support, so as to ensure their straightness and inflexibility ; just as she has assigned to sanguineous animals their bones or their fish-spines, as the case may be. To come now to Insects. In these the arrangement is quite different from that of the Cephalopods ; quite different also from that which obtains in sanguineous animals, as indeed has been already stated. For in an insect there is no distinction into soft and hard parts, but the whole body is hard, the hardness, however, being of such a character as to be more flesh-like than bone, and more earthy and bone-like than flesh. The purpose of this is to make the body of the insect less liable to get broken into pieces.

9 There is a resemblance between the osseous and the vascular systems ; for each has a central part in which it begins, and each forms a continuous whole. For no bone in the body exists as a separate thing in itself, but each is either a portion of what may be considered a continuous whole, or at any rate is linked with the rest by contact and by attachments ; so that nature may use adjoining bones either as though they were actually continuous and formed 654b
a single bone, or, for purposes of flexure, as though they were two and distinct. And similarly no blood-vessel has in itself a separate individuality ; but they all form parts of one whole. For an isolated bone, if such there were, would in the first place be unable to perform the office for the sake of which bones exist ; for, were it discontinuous and separated from the rest by a gap, it would be perfectly unable to produce either flexure or extension ; nor only so, but it would actually be injurious, acting like a thorn or an arrow lodged in the flesh. Similarly if a vessel were isolated, and not continuous with the vascular centre, it would be unable to retain the blood within it in a proper state. For it is the warmth derived from this centre that hinders the blood from coagulating ; indeed the blood, when withdrawn from its influence, becomes manifestly putrid. Now the centre or origin of the blood-vessels is the heart, and the centre or origin of the bones, in all

animals that have bones, is what is called the chine. With this all the other bones of the body are in continuity; for it is the chine that holds together the whole length of an animal and preserves its straightness. But since it is necessary that the body of an animal shall bend during locomotion, this chine, while it is one in virtue of the continuity of its parts, yet by its division into vertebrae is made to consist of many segments. It is from this chine that the bones of the limbs, in such animals as have these parts, proceed, and with it they are continuous, being fastened together by the sinews where the limbs admit of flexure, and having their extremities[1] adapted to each other, either by the one being hollowed and the other rounded,[2] or by both being hollowed and including between them a hucklebone,[3] as a connecting bolt, so as to allow of flexure and extension. For without some such arrangement these movements would be utterly impossible, or at any rate would be performed with great difficulty. There are some joints, again, in which the lower end of the one bone and the upper end of the other are alike in shape. In these cases the bones are bound together by sinews, and cartilaginous pieces are interposed in the joint, to serve as a kind of padding, and prevent the two extremities from grating against each other.

Round about the bones, and attached to them by thin fibrous bands, grow the fleshy parts, for the sake of which the bones themselves exist. For just as an artist, when he is moulding an animal out of clay or other soft substance, takes first some solid body as a basis, and round this moulds the clay, so also has nature acted in fashioning the animal body out of flesh. Thus we find all the fleshy parts, with one exception, supported by bones, which serve, when the parts are organs of motion, to facilitate flexure, and, when the parts are motionless, act as a protection. The

[1] Read *συνεχῆ πρὸς αὐτὴν τὰ τούτων ὀστᾶ τῶν μορίων* (Z) *ἐστίν, ᾗ ἔχει τὰ κῶλα κάμψιν συνδεδεμένα τοῖς* (SU) *νεύροις κτλ.*

[2] i. e. Ball and socket joints, as of hip and shoulder. The next form, containing an astragalus, is the ankle joint. The third kind mentioned includes arthrodial joints, e. g. the sterno-clavicular, carpal, &c., but probably refers more especially to the knee-joint with its semilunar cartilages.

[3] Cf. iv. 10. 690a 10 note.

ribs, for example, which enclose the chest are intended to ensure the safety of the heart and neighbouring viscera. The exception of which mention was made is the belly. 655a
The walls of this are in all animals devoid of bones; in order that there may be no hindrance to the expansion which necessarily occurs in this part after a meal, nor, in females, any interference with the growth of the foetus, which is lodged here.

Now the bones of viviparous animals, of such, that is, as are not merely externally but also internally viviparous,[1] vary but very little from each other in point of strength, which in all of them is considerable. For the Vivipara in their bodily proportions are far above other animals, and many of them occasionally grow to an enormous size, as is the case in Libya and in hot and dry countries generally. But the greater the bulk of an animal, the stronger, the bigger, and the harder, are the supports which it requires; and comparing the big animals with each other, this requirement will be most marked in those that live a life of rapine. Thus it is that the bones of males are harder than those of females; and the bones of flesh-eaters, that get their food by fighting, are harder than those of Herbivora. Of this the Lion is an example; for so hard are its bones, that, when struck, they give off sparks, as though they were stones. It may be mentioned also that the Dolphin, inasmuch as it is viviparous, is provided with bones and not with fish-spines.

In those sanguineous animals, on the other hand, that are oviparous, the bones present successive slight variations of character. Thus in Birds there are bones, but these are not so strong as the bones of the Vivipara. Then come the Oviparous fishes, where there is no bone, but merely fish-spine. In the Serpents too the bones have the character of fish-spine, excepting in the very large species, where the solid foundation of the body requires to be stronger, in order that the animal itself may be strong, the same reason prevailing as in the case of the Vivipara. Lastly, in the

[1] i.e. Of the truly viviparous, not the ovo-viviparous such as the Selachia, whose bones are cartilaginous. Cf. iv. 1. 676b 3 note.

Selachia, as they are called, the fish-spines are replaced by cartilage. For it is necessary that the movements of these animals shall be of an undulating character; and this again requires the framework that supports the body to be made of a pliable and not of a brittle substance. Moreover, in these Selachia [1] nature has used all the earthy matter on the skin; and she is unable to allot to many different parts one and the same superfluity of material.[2] Even in viviparous animals many of the bones are cartilaginous. This happens in those parts where it is to the advantage of the surrounding flesh that its solid base shall be soft and mucilaginous. Such, for instance, is the case with the ears and nostrils; for in projecting parts, such as these, brittle substances would soon get broken. Cartilage and bone are indeed fundamentally the same thing, the differences between them being merely matters of degree. Thus neither cartilage nor bone, when once cut off, grows again.[3] Now the cartilages of these land animals are without marrow, that is without any distinctly separate marrow. For the marrow, which in bones is distinctly separate, is here mixed up with the whole mass, and gives a soft and mucilaginous consistence to the cartilage. But in the Sela-
655b chia the chine, though it is cartilaginous, yet contains marrow; for here it stands in the stead of a bone.

Very nearly resembling the bones to the touch are such parts as nails, hoofs, whether solid or cloven, horns, and the

[1] The skin of the fishes called Selachia by A. is studded with numerous tubercles, granules, or spines, of bony matter; a peculiarity designated as 'placoid' by modern ichthyologists.

[2] It has been a matter of question whether the credit of being the first to put forth the law of organic equivalents should be assigned to Geoffroi St. Hilaire or to Goethe; the former of whom spoke of it as 'la loi de balancement organique', while the latter expressed it in these terms, 'Nature must save in one part in order to spend in another.' As a matter of fact, the law, whether true or false, is perfectly recognized by Aristotle, and is used by him over and over again in explanation of morphological phenomena.

[3] So also Hippocrates (*Aphor.* vii. 28); where, as also in the *Coacae Praenotiones* (Kühn i. 319), the word used is, as in this passage and *H. A.* iii. 8. 516b 33, ἀποκοπῇ, i.e. excised. But διακοπῇ—cut through—is used in another Aphorism (vi. 19) and is the object of the hostile criticism from which Galen somewhat weakly defends Hippocrates (Kühn xviii, Part i. 30).

beaks of birds, all of which are intended to serve as means of defence. For the organs which are made out of these substances, and which are called by the same names as the substances themselves, the organ hoof, for instance, and the organ horn, are contrivances to ensure the preservation of the animals to which they severally belong. In this class too must be reckoned the teeth, which in some animals have but a single function, namely the mastication of the food, while in others they have an additional office, namely to serve as weapons; as is the case with all animals that have sharp interfitting teeth or that have tusks. All these parts are necessarily of a solid and earthy character; for the value of a weapon depends on such properties. Their earthy character explains how it is that all such parts are more developed in four-footed vivipara than in man. For there is always more earth in the composition of these animals than in that of the human body. However, not only all these parts but such others as are nearly connected with them, skin for instance, bladder, membrane, hairs, feathers, and their analogues, and any other similar parts that there may be, will be considered farther on with the heterogeneous parts.[1] There we shall inquire into the causes which produce them, and into the objects of their presence severally in the bodies of animals. For, as with the heterogeneous parts, so with these, it is from a consideration of their functions that alone we can derive any knowledge of them. The reason for dealing with them at all in this part of the treatise, and classifying them with the homogeneous parts, is that under one and the same name are confounded the entire organs and the substances of which they are composed. But of all these substances flesh and bone form the basis. Semen and milk were also passed over when we were considering the homogeneous fluids. For the treatise on Generation[2] will afford a more suitable place for their examination, seeing that the former

[1] Cf. as to Bladder, iii. 8; Membrane, iii. 11; Hairs, ii. 14; Feathers, iv. 12. 692b 10 sq.; Nails, iv. 10. 687b 23 sq.; Hoofs, iv. 10. 690a 4; Horns, iii. 2; Beaks, iii. 1. 662a 29 sq.; Teeth, iii. 1. 661a 34 sq.

[2] *G. A.* i. 17–ii. 3, iv. 8.

of the two is the very foundation of the thing generated, while the latter is its nourishment.

Let us now make, as it were, a fresh beginning, and con- 10
sider the heterogeneous parts, taking those first which are the first in importance. For in all animals, at least[1] in all the perfect kinds, there are two parts more essential than the rest, namely the part which serves for the ingestion of food, and the part which serves for the discharge of its residue. For without food growth and even existence is impossible. Intervening[2] again between these two parts there is invariably a third, in which is lodged the vital principle. As for plants, though they also are included by us among things that have life, yet are they without any part for the discharge of waste residue. For the food which they absorb from the ground is already concocted, and they give off as its equivalent their seeds and fruits.
656a Plants, again, inasmuch as they are without locomotion, present no great variety in their heterogeneous parts. For, where the functions are but few, few also are the organs required to effect them. The configuration of plants is a matter then for separate consideration. Animals, however, that not only live but feel, present a greater multiformity of parts, and this diversity is greater in some animals than in others, being most varied in those to whose share has fallen not mere life but life of high degree. Now such an animal is man. For of all living beings with which we are acquainted man alone partakes of the divine, or at any rate partakes of it in a fuller measure than the rest. For this reason, then, and also because his external parts and their forms are more familiar to us than those of other animals, we must speak of man first; and this the more fitly, because in him alone do the natural parts hold the natural position; his upper part being turned towards that which is upper in the universe. For, of all animals, man alone stands erect.

In man, then, the head is destitute of flesh; this being

[1] For καί read τοῖς γε.
[2] This sentence is transposed from ll. 36–37.

the necessary consequence of what has already been stated[1] concerning the brain. There are, indeed, some[2] who hold that the life of man would be longer than it is, were his head more abundantly furnished with flesh; and they account for the absence of this substance by saying that it is intended to add to the perfection of sensation. For the brain they assert to be the organ of sensation; and sensation, they say, cannot penetrate to parts that are too thickly covered with flesh. But neither part of this statement is true. On the contrary, were the region of the brain thickly covered with flesh, the very purpose for which animals are provided with a brain would be directly contravened. For the brain would itself be heated to excess and so unable to cool any other part; and, as to the other half of their statement, the brain cannot be the cause of any of the sensations, seeing that it is itself as utterly without feeling as any one of the excretions.[3] These writers see that certain of the senses are located in the head, and are unable to discern the reason for this; they see also that the brain is the most peculiar of all the animal organs; and out of these facts they form an argument, by

[1] Cf. ii. 7.

[2] e.g. Plato in the *Timaeus* (75 B), who probably borrowed the opinion, as Galen says he did his physiology generally, from Hippocrates. Democritus also had taught that the sovereign part of the soul was in the head; and Diogenes of Apollonia, more directly, had held that the brain was the seat of sensation, being surrounded by a layer of hot dry air, which was in connexion with the sense-organs by means of the blood-vessels, and so sympathized with their motions and affections (cf. Grote's *Plato*, i. 65).

[3] A.'s chief reasons for refusing to admit that the brain was the sensory centre were as follows. (1) It was insensible to touch (ii. 10. 656a 23; ii. 7. 652b 5). (2) There was no brain or analogous organ in any of the bloodless animals, cephalopods excepted (ii. 7. 652b 25). (3) It was cold and bloodless (ii. 7. 652a 33). (4) It was not anatomically connected with the sense-organs, notably with those of touch and taste (ii. 7. 652b 3).

On the other hand, the heart (1) was palpably affected in emotion or when pain or pleasure was felt (iii. 6. 669a 19); (2) was present, or an analogous organ, in all animals (iii. 4. 665b 10; *G. A.* iv. 4. 771a 3); (3) was the source of heat and of the blood (iii. 5. 667b 26); (4) was in anatomical connexion, through the blood-vessels, with all the sense-organs (*G. A.* ii. 6. 744a 3); (5) was the first part to be formed in the embryo, the 'primum vivens, ultimum moriens' (*G. A.* ii. 5. 741b 20); (6) was in a central position befitting the supreme organ (iii. 7. 670a 24).

which they link sensation and brain together. It has, however, already been clearly set forth in the treatise on Sensation, that it is the region of the heart that constitutes the sensory centre. There also it was stated that two of the senses, namely touch and taste, are manifestly in immediate connexion with the heart;[1] and that as regards the other three, namely hearing, sight, and the centrally placed sense of smell, it is the character of their sense-organs which causes them to be lodged as a rule in the head. Vision is so placed in all animals. But such is not invariably the case with hearing or with smell. For fishes and the like hear and smell, and yet have no visible organs for these senses in the head;[2] a fact which demonstrates the accuracy of the opinion here maintained. Now that vision, whenever it exists, should be in the neighbourhood
656b of the brain is but what one would rationally expect. For the brain is fluid and cold, and vision is of the nature of water, water being of all transparent substances the one most easily confined. Moreover it cannot but necessarily be that the more precise senses will have their precision rendered still greater if ministered to by parts that have the purest blood. For the motion of the heat of blood destroys sensory activity. For these reasons the organs of the precise senses are lodged in the head.

It is not only the fore part of the head that is destitute of flesh, but the hind part also. For, in all animals that have a head, it is this head which more than any other part requires to be held up. But, were the head heavily laden with flesh, this would be impossible; for nothing so burdened can be held upright. This is an additional proof that the absence of flesh from the head has no reference to

[1] Cf. *De Sensu*, 2. 439a 1.

[2] One might suppose from this passage that the excavations near the anterior part of the snout, which constitute in fishes the external organs of smell, had entirely escaped A.'s notice. But this was not so, as appears from a passage (*H. A.* iv. 8. 533b 1), where he mentions these recesses, and says that some consider them to be organs of sense. This, however, he will not admit, because 'the passages (πόροι) do not appear to lead to the brain, but are either blind or lead to the gills'. His notion was that in fishes the gills were the external organs of smell (cf. ii. 16. 659b 16 note).

brain sensation. For there is no brain in the hinder part of the head,[1] and yet this is as much without flesh as is the front.

In some animals hearing as well as vision is lodged in the region of the head. Nor is this without a rational explanation. For what is called the empty space is full of air, and the organ of hearing is, as we say, of the nature of air. Now there are channels [2] which lead from the eyes to the blood-vessels that surround the brain; and similarly there is a channel which leads back again from each ear and connects it with the hinder part of the head. But no part that is without blood is endowed with sensation, as neither is the blood itself, but only some one of the parts that are formed of blood.[3]

[1] An error borrowed from Hippocrates (Kühn's edit. i. 183); but very possibly deriving support from examination of the brain of cold-blooded animals. For in Fishes and Reptiles the brain is not large enough to fill the cranial cavity, a character to which Lamarck attached great importance in distinguishing these groups from Mammals and Birds (*Phil. Zool.* i. 276, Martin's edit.). In the tortoise, for instance, the area of a vertical section of the brain, according to Desmoulins (Todd, *Cyclop. of An. and Phys.* i. 724), is nearly a third less than the area of the cavity. So also the brain completely fills the brain-case in embryonic fishes, but in the adult only occupies a small part of it, as its growth is by no means proportionate to that of the cranium itself. That A. had noticed this is probable from his saying (*G. A.* ii. 6. 744a 17) that the brain of animals is at first of large size, but afterwards falls in and becomes of smaller dimensions. So also in Cephalopods, animals specially studied by A., and with whose so-called brain he was acquainted, the cavity in which the ganglia are lodged is much larger than the ganglia themselves.

[2] Frantzius, following Schneider, interprets these channels or πόροι to mean nerves, and, were the πόροι of the eye alone in question, there are passages (*H. A.* i. 16. 495a 11–18; *G. A.* ii. 6. 744a 9) which would make this view highly probable. But A. (*G. A.* ii. 6. 743b 36) speaks of *all* the sense-organs as being on πόροι, and describes the πόροι of the ears and nose as full of connate air, and running to the blood-vessels on the outside of the brain and so communicating with the heart. The present passage, moreover, seems to imply that the internal auditory πόρος is of the same character as the external auditory meatus, that is to say is an air-duct. Meyer (*Thierkunde*, p. 428) takes the πόροι to be blood-vessels. It seems, however, unnecessary to assume that some one exclusive structure applicable to all the sense-organs is indicated. The nerves of the eye, the supposed air-ducts of the ears and nose, the blood-vessels of the organs generally, are all πόροι; all, that is, are channels by which the sense-organs communicate with the heart, either directly or with the intermediation of the φλέβια τὰ περὶ τὸν ἐγκέφαλον (*G. A.* ii. 6. 744a 4).

[3] The argument is this: The channels from the eyes end in the

The brain in all animals that have one is placed in the front part of the head; because the direction in which sensation acts is in front; and because the heart, from which sensation proceeds, is in the front part of the body; and lastly because the instruments of sensation are the blood-containing parts, and the cavity in the posterior part of the skull is destitute of blood-vessels.

As to the position of the sense-organs, they have been arranged by nature in the following well-ordered manner. The organs of hearing are so placed as to divide the circumference of the head into two equal halves; for they have to hear not only sounds which are directly in a line with themselves, but sounds from all quarters. The organs of vision are placed in front, because sight is exercised only in a straight line, and moving as we do in a forward direction it is necessary that we should see before us, in the direction of our motion. Lastly, the organs of smell are placed with good reason between the eyes. For as the body consists of two parts, a right half and a left, so also each organ of sense is double. In the case of touch this is not apparent, the reason being that the primary organ of this sense is not the flesh or analogous part, but lies internally.[1] In the case of taste, which is merely a modification of touch and which is placed in the tongue, the fact is more apparent than in the case of touch, but still not
657a so manifest as in the case of the other senses. However, even in taste it is evident enough; for in some animals the tongue is plainly forked. The double character of the sensations is, however, more conspicuous in the other organs of sense. For there are two ears and two eyes, and the nostrils, though joined together, are also two. Were these latter otherwise disposed, and separated from each other as

blood-vessels outside the brain, and blood itself is insensible. The channels from the ears end in the void space, where there are no blood-vessels; and no part without blood-vessels is sensitive. Neither the sensibility of the eyes nor that of the ears can therefore be explained simply by their connexion with the interior of the cranium.

A short sentence is here omitted, as being partly unintelligible, partly empty iteration. Part of it, moreover, is wanting in E, one of the best MSS.

[1] Cf. ii. 8. 653b 30 note.

are the ears, neither they nor the nose in which they are placed would be able to perform their office. For in such animals as have nostrils olfaction is effected by means of inspiration, and the organ of inspiration is placed in front and in the middle line. This is the reason why nature has brought the two nostrils together and placed them as the central of the three sense-organs, setting them side by side on a level with each other, to avail themselves of the inspiratory motion. In other animals than man the arrangement of these sense-organs is also such as is adapted in
11 each case to the special requirements. For instance, in quadrupeds the ears stand out freely from the head and are set to all appearance above the eyes. Not that they are in reality above the eyes; but they seem to be so, because the animal does not stand erect, but has its head hung downwards. This being the usual attitude of the animal when in motion, it is of advantage that its ears shall be high up and movable; for by turning themselves about they can the better take in sounds from every quarter.
12 In birds, on the other hand, there are no ears, but only the auditory passages. This is because their skin is hard and because they have feathers instead of hairs, so that they have not got the proper material for the formation of ears. Exactly the same is the case with such oviparous quadrupeds as are clad with scaly plates, and the same explanation applies to them. There is also one of the viviparous quadrupeds, namely the seal, that has no ears but only the auditory passages. The explanation of this is that the seal, though a quadruped, is a quadruped of stunted formation.

13 Men, and Birds, and Quadrupeds, viviparous and oviparous alike, have their eyes protected by lids. In the Vivipara there are two of these; and both are used by these animals not only in closing the eye, but also in the act of blinking; whereas the oviparous quadrupeds, and the heavy-bodied birds[1] as well as some others, use only

[1] That is the Gallinaceous birds (*H. A.* ii. 8. 613^b 6).

the lower lid to close the eye;[1] while birds blink by means of a membrane that issues from the canthus. The reason for the eyes being thus protected is that nature has made them of fluid consistency, in order to ensure keenness of vision. For had they been covered with hard skin, they would, it is true, have been less liable to get injured by anything falling into them from without, but they would not have been sharp-sighted. It is then to ensure keenness of vision that the skin over the pupil is fine and delicate; while the lids are superadded as a protection from injury. It is as a still further safeguard that all these animals blink,
657b and man most of all; this action (which is not performed from deliberate intention but from a natural instinct) serving to keep objects from falling into the eyes; and being more frequent in man than in the rest of these animals, because of the greater delicacy of his skin. These lids are made of a roll of skin; and it is because they are made of skin and contain no flesh that neither they, nor the similarly constructed prepuce, unite again when once cut.[2]

As to the oviparous quadrupeds, and such birds as resemble them in closing the eye with the lower lid, it is the hardness of the skin of their heads which makes them do so. For such birds as have heavy bodies are not made for flight; and so the materials which would otherwise have gone to increase the growth of the feathers are diverted thence, and used to augment the thickness of the skin. Birds therefore of this kind close the eye with the lower lid; whereas pigeons and the like use both upper and lower lids for the purpose. As birds are covered with feathers, so oviparous quadrupeds are covered with scaly plates; and these in all

[1] In birds, as a rule, as also in Chelonia, in crocodiles, and in frogs, the lower lid is much larger and more movable than the upper, and it is with it therefore that the eye is closed in sleep. There are, however, some few exceptions, and of these the owl is one, as noticed by A. elsewhere (*H. A.* ii. 12. 504a 26). A few sentences later it is said that pigeons use both lids to close the eye, which is also a correct observation.

[2] This is an unfortunate statement, borrowed however from Hippocrates (Kühn's ed. i. 319; iii. 752). Firstly, the presence of flesh, i.e. of muscular tissue, is not essential for reunion after section; secondly, the eyelid does contain muscular tissue; and, lastly, cuts both in it and the prepuce can be made to unite by proper appliances.

their forms are harder than hairs, so that the skin also to which they belong is harder than the skin of hairy animals. In these animals, then, the skin on the head is hard, and so does not allow of the formation of an upper eyelid, whereas lower down the integument is of a flesh-like character, so that the lower lid can be thin and extensible.

The act of blinking is performed by the heavy-bodied birds[1] by means of the membrane already mentioned, and not by this lower lid. For in blinking rapid motion is required, and such is the motion of this membrane, whereas that of the lower lid is slow. It is from the canthus that is nearest to the nostrils that the membrane comes. For it is better to have one starting-point for nictitation than two; and in these birds this starting-point is the junction of eye and nostrils, an anterior starting-point being preferable to a lateral one. Oviparous quadrupeds do not blink in like manner as the birds;[2] for, living as they do on the ground, they are free from the necessity of having eyes of fluid consistency and of keen sight, whereas these are essential requisites for birds, inasmuch as they have to use their eyes at long distances. This too explains why birds with talons, that have to search for prey by eye from aloft, and therefore soar to greater heights than other birds, are sharp-sighted; while common fowls and the like, that live on the ground and are not made for flight, have no such keenness of vision. For there is nothing in their mode of life which imperatively requires it.

Fishes and Insects and the hard-skinned Crustacea present certain differences in their eyes, but so far resemble each other as that none of them have eyelids.[3] As for the hard-skinned Crustacea it is utterly out of the question that they should have any; for an eyelid, to be of use, requires the action of the skin[4] to be rapid. These animals then have

[1] And by all other birds also (cf. *H. A.* ii. 12. 504ᵃ 26).

[2] A. both here and elsewhere speaks erroneously of a nictitating membrane as peculiar to birds. For, though it is especially well developed in birds, yet it is to be found in numerous reptiles, amphibia, and sharks, not to mention some mammals.

[3] There are exceptions among fishes, particularly in sharks.

[4] Read ταχεῖαν τὴν δερματικὴν ἔχει ἐργασίαν.

no eyelids and, in default of this protection, their eyes are hard, just as though the lid were attached to the surface of the eye, and the animal saw through it. Inasmuch, however, as such hardness must necessarily blunt the sharpness of vision, nature has endowed the eyes of Insects, and
658a still more those of Crustacea,[1] with mobility (just as she has given some quadrupeds movable ears), in order that they may be able to turn to the light and catch its rays, and so see more plainly. Fishes, however, have eyes of a fluid consistency. For animals that move much about have to use their vision at considerable distances. If now they live on land, the air in which they move is transparent enough. But the water in which fishes live is a hindrance to sharp sight, though it has this advantage over the air, that it does not contain so many objects to knock against the eyes. The risk of collision being thus small, nature, who makes nothing in vain, has given no eyelids to fishes, while to counterbalance the opacity of the water she has made their eyes of fluid consistency.

All animals that have hairs on the body have lashes on **14**
the eyelids; but birds and animals with scale-like plates, being hairless, have none.[2] The Libyan ostrich, indeed, forms an exception; for, though a bird, it is furnished with eyelashes. This exception, however, will be explained hereafter. Of hairy animals, man alone has lashes on both lids. For in quadrupeds there is a greater abundance of hair on the back than on the under side of the body; whereas in man the contrary is the case, and the hair is more abundant on the front surface than on the back. The reason for this is that hair is intended to serve as a protection to its possessor. Now, in quadrupeds, owing to

[1] A.'s knowledge of Crustacea was confined, or nearly so, to Podophthalmata, in which the eyes are supported on movable peduncles. Insects have, almost invariably, sessile and motionless eyes; and though in a few instances the eyes are on peduncles, these peduncles are not movable like those of Crustacea.

[2] Birds, as a rule, have no eyelashes. There are, however, a few exceptions, and of these the Ostrich is one.—Casaubon rightly explains the construction—'voluit dicere et scripsisset alius, *ὄρνιθες δὲ οὐκ ἔχουσιν οὐδὲ τῶν φολιδωτῶν οὐδέν*'.

their inclined attitude, the under or anterior surface does not require so much protection as the back, and is therefore left comparatively bald, in spite of its being the nobler of the two sides. But in man, owing to his upright attitude, the anterior and posterior surfaces of the body are on an equality as regards need of protection. Nature therefore has assigned the protective covering to the nobler of the two surfaces;[1] for invariably she brings about the best arrangement of such as are possible. This then is the reason that there is no lower eyelash in any quadruped; though in some a few scattered hairs sprout out under the lower lid.[2] This also is the reason that they never have hair in the axillae, nor on the pubes, as man has. Their hair, then, instead of being collected in these parts, is either thickly set over the whole dorsal surface, as is the case for instance in dogs, or, sometimes, forms a mane, as in horses and the like, or as in the male lion, where the mane is still more flowing and ample. So, again, whenever there is a tail of any length, nature decks it with hair, with long hair if the stem of the tail be short, as in horses, with short hair if the stem be long, regard also being had to the condition of the rest of the body. For nature invariably gives to one part what she subtracts from another. Thus when she has covered the general surface of an animal's body with an excess of hair, she leaves a deficiency in the region of the tail. This, for instance, in the case with bears.

No animal has so much hair on the head as man. This, in the first place, is the necessary result of the fluid character of his brain, and of the presence of so many sutures in his skull. For wherever there is the most fluid and the most heat, there also must necessarily occur the

[1] Cf. ii. 2. 648a 13 note.

[2] So far as I can ascertain it is true that man is the only mammal with a distinct marginal lower eyelash, with the exception of some monkeys, an exception elsewhere (*H. A.* ii. 8. 502a 31) recognized by A., and some few antelopes. In very many mammals, especially the smaller kinds, there are no eyelashes at all. In the larger kinds, as a rule, the upper lash is well developed and marginal, while the lower lash is represented, as A. rightly says, by some long straggling hairs set below the lid, not on its margin.

greatest outgrowth. But, secondly, the thickness of the hair in this part has a final cause, being intended to protect the head, by preserving it from excess of either heat or cold. And as the brain of man is larger and more fluid than that of any other animal, it requires a proportionately greater amount of protection. For the more fluid a substance is, the more readily does it get excessively heated or excessively chilled, while substances of an opposite character are less liable to such injurious affections.

These, however, are matters which by their close connexion with eyelashes have led us to digress from our real topic, namely the cause to which these lashes owe their existence. We must therefore defer any further remarks we may have to make on these matters till the proper occasion arises and then return to their consideration.

Both eyebrows and eyelashes exist for the protection of **15**
the eyes ; the former that they may shelter them, like the eaves of a house, from any fluids that trickle down from the head ;[1] the latter to act like the palisades which are sometimes placed in front of enclosures, and keep out any objects which might otherwise get in. The brows are placed over the junction of two bones, which is the reason that in old age they often become so bushy as to require cutting. The lashes are set at the terminations of small blood-vessels. For the vessels come to an end where the skin itself terminates ; and, in all places where these endings occur, the exudation of moisture of a corporeal character necessitates the growth of hairs,[2] unless there be some operation of nature which interferes, by diverting the moisture to another purpose.

[1] The explanation and the comparison are borrowed from Xenophon (*Mem.* i. 4. 6), who puts them into the mouth of Socrates.

[2] A. knew that the blood passed from the heart to the various parts by the vessels, but scarcely recognized its returning. Thus when the blood reached the peripheral ends of the vessels, it had to be disposed of in some form or other ; that which escaped internally formed the viscera, that which escaped externally formed hair and the like. Thus the hair was in a certain sense an excretion (ii. 650a 22 note). So also was it regarded by Bacon (*Nat. Hist.* cent. i, sect. 58) and Shakespeare— 'Your bedded hair, like life in excrements,
Starts up, and stands on end' (*Hamlet* iii. 4).

16 Viviparous quadrupeds, as a rule, present no great variety of form in the organ of smell. In those of them, however, whose jaws project forwards and taper to a narrow end, so as to form what is called a snout, the nostrils are placed in this projection, there being no other available plan; while, in the rest, there is a more definite demarcation between nostrils and jaws. But in no animal is this part so peculiar as in the elephant, where it attains an extraordinary size and strength. For the elephant uses its nostril as a hand; this being the instrument with 659a
which it conveys food, fluid and solid alike, to its mouth. With it, too, it tears up trees, coiling it round their stems. In fact it applies it generally to the purposes of a hand. For the elephant has the double character of a land animal, and of one that lives in swamps. Seeing then that it has to get its food from the water,[1] and yet must necessarily breathe, inasmuch as it is a land animal and has blood; seeing, also, that its excessive weight prevents it from passing rapidly from water to land, as some other sanguineous vivipara that breathe can do, it becomes necessary that it shall be suited alike for life in the water and for life on dry land. Just then as divers are sometimes provided with instruments for respiration, through which they can draw air from above the water, and thus may remain for a long time under the sea,[2] so also have elephants been furnished by nature with their lengthened nostril; and, whenever they have to traverse the water, they lift this up above the surface and breathe through it.[3] For the elephant's proboscis, as already said, is a nostril. Now it would have

[1] The elephant is much given to bathing: but A. appears to have entertained an exaggerated idea of its aquatic habits, and to have misinterpreted its reasons for betaking itself to the water; imagining that it went there not merely to slake its thirst or for the luxury of a cold bath, but because it depended, of course in its wild state, on water-plants for its sustenance!

[2] From this curious passage it would appear that the ancients were already acquainted with some form of diving apparatus corresponding to the submarine helmet and tubes in use at the present time. It may, however, have been some very simple instrument, such as the reed by means of which Australian natives (Tylor, *Anthrop.* p. 208) are said to be able to swim for a distance under water, so as to approach a flock of ducks without being seen.

[3] Cf. *H. A.* ix. 46. 630b 27. The elephant does in fact use its trunk in the way described when crossing a deep river (cf. Tennent, *Ceylon*, ii. 310).

been impossible for this nostril to have the form of a proboscis, had it been hard and incapable of bending. For its very length would then have prevented the animal from supplying itself with food, being as great an impediment as the horns of certain oxen, that are said [1] to be obliged to walk backwards while they are grazing. It is therefore soft and flexible, and, being such, is made, in addition to its own proper functions, to serve the office of the fore-feet; nature in this following her wonted plan of using one and the same part for several purposes. For in polydactylous quadrupeds the fore-feet are intended not merely to support the weight of the body, but to serve as hands. But in elephants, though they must be reckoned [2] polydactylous, as their foot has neither cloven nor solid hoof, the fore-feet, owing to the great size and weight of the body, are reduced to the condition of mere supports; and indeed their slow motion and [3] unfitness for bending make them useless for any other purpose. A nostril, then, is given to the elephant for respiration, as to every other animal that has a lung, and is lengthened out and endowed with its power of coiling because the animal has to remain for considerable periods of time in the water, and is unable to pass thence to dry ground with any rapidity. But as the feet are shorn of their full office, this same part is also, as already said, made by nature to supply their place, and give such help as otherwise would be rendered by them.

As to other sanguineous animals, the Birds, the Serpents,
659b and the Oviparous quadrupeds, in all of them there are the nostril-holes, placed in front of the mouth; but in none are there any distinctly formed nostrils, nothing in fact which can be called nostrils except from a functional point of view. A bird at any rate has nothing which can properly be called a nose. For its so-called beak is a substitute for jaws. The reason for this is to be found in the natural conformation of birds. For they are winged bipeds; and

[1] This story comes from Herodotus (iv. 183).

[2] Although the toes are not separate nor clearly defined, ἀσχίστους καὶ ἠρέμα διηρθρωμένους. (Cf. *H. A.* iii. 9. 517a 32.)

[3] A. does not mean that the elephant has no joints in its legs, for he specially repudiates this vulgar error (*H. A.* ii. 1. 498a 9).

this makes it necessary that their head and neck shall be of light weight; just as it makes it necessary that their breast[1] shall be narrow. The beak therefore with which they are provided is formed of a bone-like substance, in order that it may serve as a weapon as well as for nutritive purposes, but is made of narrow dimensions to suit the small size of the head. In this beak are placed the olfactory passages. But there are no nostrils; for such could not possibly be placed there.

As for those animals that have no respiration, it has already been explained[2] why it is that they are without nostrils, and perceive odours either through gills, or through a blow-hole, or, if they are insects, by the hypozoma;[3] and how the power of smelling depends, like their motion, upon the innate spirit of their bodies, which in all of them is implanted by nature and not introduced from without.

Under the nostrils are the lips, in such sanguineous animals, that is, as have teeth. For in birds, as already has been said, the purposes of nutrition and defence are fulfilled by a bone-like beak, which forms a compound substitute for teeth and lips. For supposing that one were

[1] Cf. iv. 12. 693b 17 note.

[2] Perhaps this refers to *De Sensu* 5. 444b 6 sq.

[3] By *hypozoma* A. designates no distinct organ or structure, but the indefinite mid part of the trunk, that in the human body is called the waist, but in other animals has no name. In insects this region is marked by a narrow constriction, but A. also speaks of a hypozoma in fishes where there is no such constriction (*G. A.* i. 8. 718b 1). It is not difficult to understand why A. located the sense of smell in or near this region of the insect's body. Arguing by analogy from the higher animals, A. believed that the organ of smell was inseparable from the organ of respiration, or, in the lower animals, of refrigeration. He accordingly located smell in the gills of fishes, in the blowpipe of Cetacea, and in insects, in a specially thin part of the integument, covering a fissure just below the *hypozoma*, and serving, as he thought, for escape of heat and production of sounds (*De Resp.* 9. 475a 1–19; *H. A.* iv. 9. 535b 8). This refers to the so-called 'drums' of cicadae and the 'tympana' of grasshoppers, to which A. apparently supposed there was something correspondent in other insects; meaning perhaps the thinner integument between the successive rings of the abdomen. The alternate contractions and dilatations, which are visible in an insect's abdomen, and which are in reality respiratory, were attributed by him to the refrigerating motion of the 'connate spirit'. It must be by inadvertence that the blowpipe of Cetacea is mentioned, for A. is speaking of animals that have no lungs, and he well knew that Cetacea were not of these.

to cut off a man's lips, unite his upper teeth together, and similarly his under ones, and then were to lengthen out the two separate pieces thus formed, narrowing them on either side and making them project forwards, supposing, I say, this to be done, we should at once have a bird-like beak.

The use of the lips in all animals except man is to preserve and guard the teeth; and thus it is that the distinctness with which the lips are formed is in direct proportion to the degree of nicety and perfection with which the teeth are fashioned. In man the lips are soft and flesh-like and capable of separating from each other. Their purpose, as in other animals, is to guard the teeth, but they are more especially intended to serve a higher office, contributing in common with other parts to man's faculty of speech. For just as nature has made man's tongue unlike that of other animals, and, in accordance
660a with what I have said [1] is her not uncommon practice, has used it for two distinct operations, namely for the perception of savours and for speech, so also has she acted with regard to the lips, and made them serve both for speech and for the protection of the teeth. For vocal speech consists of combinations of the letters, and most of these it would be impossible to pronounce, were the lips not moist, nor the tongue such as it is. For some letters are formed by closures of the lips and others by applications of the tongue. But what are the differences presented by these and what the nature and extent of such differences, are questions to which answers must be sought from those who are versed in metrical science.[2] It was necessary that the two parts which we are discussing should, in conformity with the requirements, be severally adapted to fulfil the office mentioned above, and be of appropriate character. Therefore are they made of flesh, and flesh is softer in man than in any other animal, the reason

[1] Cf. 659a 21.

[2] The so-called Metrical Science had for its province everything relating to words considered merely as sounds, and ranged therefore from prosody and the laws of versification back to the elementary vocal sounds and the mechanism of their production. Cf. *Poetics* 20.

for this being that of all animals man has the most delicate sense of touch.

17 The tongue is placed under the vaulted roof of the mouth. In land animals it presents but little diversity. But in other animals it is variable, and this whether we compare them as a class with such as live on land, or compare their several species with each other. It is in man that the tongue attains its greatest degree of freedom, of softness, and of breadth; the object of this being to render it suitable for its double function. For its softness fits it for the perception of savours, a sense which is more delicate in man than in any other animal, softness being most impressionable by touch, of which sense taste is but a variety. This same softness again, together with its breadth, adapts it for the articulation of letters and for speech. For these qualities, combined with its freedom from attachment, are those which suit it best for advancing and retiring in every direction. That this is so is plain, if we consider the case of those who are tongue-tied in however slight a degree. For their speech is indistinct and lisping; that is to say there are certain letters which they cannot pronounce. In being broad is comprised the possibility of becoming narrow; for in the great the small is included, but not the great in the small.

What has been said explains why, even among birds, those that are most capable of pronouncing letters are such as have the broadest tongues;[1] and why the viviparous and sanguineous quadrupeds, where the tongue is hard and thick and not free in its motions, have a very limited vocal articulation. Some birds have a considerable variety of notes. These are the smaller kinds.[2] But it is the birds with talons that have the broader tongues. All birds use their tongues to communicate with each other. But some do this in a greater degree than the rest; so that in some 660b
cases it even seems as though actual instruction were

[1] In parrots, included by A. among the birds with talons, the tongue is 'épaisse, charnue et arrondie; deux circonstances qui leur donnent la plus grande facilité à imiter la voix humaine' (Cuvier, *Reg. An.* i. 461).

[2] Cf. *H. A.* iv. 9. 536a 24.

imparted from one to another by its agency. These, however, are matters which have already been discussed in the Researches concerning Animals.[1]

As to those oviparous and sanguineous animals that live not in the air but on the earth, their tongue in most cases is tied down and hard, and is therefore useless for vocal purposes; in the serpents, however, and in the lizards it is long and forked, so as to be suited for the perception of savours. So long indeed is this part in serpents, that though small while in the mouth it can be protruded to a great distance. In these same animals it is forked and has a fine and hair-like extremity, because of their great liking for dainty food. For by this arrangement they derive a twofold pleasure from savours, their gustatory sensation being as it were doubled.

Even some bloodless animals have an organ that serves for the perception of savours; and in sanguineous animals such an organ is invariably present. For even in such of these as would seem to an ordinary observer to have nothing of the kind, some of the fishes for example, there is a kind of shabby representative of a tongue,[2] much like what exists in river crocodiles. In most of these cases the apparent absence of the part can be rationally explained on some ground or other. For in the first place the interior of the mouth in animals of this character is invariably spinous. Secondly, in water animals there is but short space of time for the perception of savours, and as the use of this sense is thus of short duration, shortened also is the separate part which subserves it. The reason for their food being so rapidly transmitted to the stomach is that they cannot possibly spend any time in sucking out the juices; for were they to attempt to do so, the water would make its way in during the process. Unless therefore one pulls their mouth very widely open, the projection of this part is quite invisible. The region exposed by thus

[1] Cf. *H. A.* ii. 12. 504b 1; iv. 9. 536a 20–b 19; ix. 1. 608a 17.

[2] Cf. *H. A.* ii. 13. 505a 31. Many fishes have no tongue. In none is it protrusible, being at best an insignificant ligamentary or cellular body, scarcely projecting from the glosso-hyoid. Cf. Owen (*Vert.* i. 411), Cuvier (*An. Comp.* ii. 681), Günther (*St. of Fishes*, p. 119).

opening the mouth is spinous; for it is formed by the close apposition of the gills, which are of a spinous character.

In crocodiles the immobility of the lower jaw also contributes in some measure to stunt the development of the tongue. For the crocodile's tongue is adherent to the lower jaw. For its upper and lower jaws are, as it were, inverted, it being the upper jaw which in other animals is the immovable one. The tongue, however, of this animal is not attached to the upper jaw, because that would interfere with the ingestion of food, but adheres to the lower jaw, because this is, as it were, the upper one which has changed its place.[1] Moreover, it is the crocodile's lot, though a land animal, to live the life of a fish, and this again necessarily involves an indistinct formation of the part in question.

The roof of the mouth resembles flesh, even in many of the fishes; and in some of the river species, as for instance in the fishes known as Cyprini,[2] is so very flesh-like and soft as to be taken by careless observers for a tongue. The 661a
tongue of fishes, however, though it exists as a separate part, is never formed with such distinctness as this, as has been already explained. Again, as the gustatory sensibility is intended to serve animals in the selection of food, it is not diffused equally over the whole surface of the tongue-like organ, but is placed chiefly in the tip; and for this reason it is the tip which is the only part of the tongue separated in fishes from the rest of the mouth. As all animals are sensible to the pleasure derivable from food, they all feel a desire for it. For the object of desire is the pleasant. The part, however, by which food produces the sensation is not precisely alike in all of them, but while in some it is free

[1] The exact drift of this passage is not very evident. I take it that A. thinks it necessary to explain why the tongue, if it adheres to one jaw, does not adhere to that which in his view is the nobler, namely the upper (ii. 2. 648a 11 note). His explanation is that in reality the tongue does adhere to the upper jaw; but that the upper jaw has been brought into the position of the lower one, as its immobility testifies, lest the adherence of the tongue to it should interfere with deglutition.

[2] In the Cyprinoids the palate is cushioned with a thick soft vascular substance, remarkable for its great irritability. This is still commonly known in France as 'langue de carpe' (Cuvier, *R. An.* ii. 270).

from attachments, in others, where it is not required for vocal purposes, it is adherent. In some again it is hard, in others soft or flesh-like. Thus even the Crustacea, the Carabi for instance and the like, and the Cephalopods, such as the Sepias and the Poulps, have some such part inside the mouth. As for the Insects, some of them have the part which serves as tongue inside the mouth, as is the case with ants, and as is also the case with many Testacea, while in others it is placed externally. In this latter case it resembles a sting, and is hollow and spongy, so as to serve at one and the same time for the tasting and for the sucking up of nutriment. This is plainly to be seen in flies and bees and all such animals, and likewise in some of the Testacea. In the Purpurae,[1] for instance, so strong is this part that it enables them to bore holes through the hard covering of shell-fish, of the spiral snails, for example, that are used as bait to catch them. So also the gad-flies and cattle-flies[2] can pierce through the skin of man, and some of them even through the skins of other animals. Such, then, in these animals is the nature of the tongue, which is thus as it were the counterpart of the elephant's nostril. For as in the elephant the nostril is used as a weapon, so in these animals the tongue serves as a sting.

In all other animals the tongue agrees with the description already given.

[1] Under Purpura are probably included all the various species of Murex and Purpura from which purple dye was obtainable. Of these the most important seem to have been *M. trunculus* and *M. brandaris* (Woodward, *R. & F. Shells*, p. 106). As to the power possessed by *P. lapillus* of boring through shells by means of its armed tongue, see Forbes and Hanley, *Brit. Mollusca*, iii. 385.

[2] By Oestri and Myopes, translated vaguely as Gad-flies and Cattle-flies, are probably meant some species or other of Tabanus.

BOOK III

1 We have next to consider the teeth, and with these the mouth, that is the cavity which they enclose and form. The teeth have one invariable office, namely the reduction 661b
of food; but besides this general function they have other special ones, and these differ in different groups. Thus in some animals the teeth serve as weapons; but this with a distinction. For there are offensive weapons and there are defensive weapons; and while in some animals, as the wild Carnivora, the teeth answer both purposes, in many others, both wild and domesticated, they serve only for defence. In man the teeth are admirably constructed for their general office, the front ones being sharp, so as to cut the food into bits, and the hinder ones broad and flat, so as to grind it to a pulp; while between these and separating them are the dog-teeth, which, in accordance with the rule that the mean partakes of both extremes, share in the characters of those on either side, being broad in one part but sharp in another.[1] Similar distinctions of shape are presented by the teeth of other animals, with the exception of those whose teeth are one and all of the sharp kind. In man, however, the number and the character even of these sharp teeth have been mainly determined by the requirements of speech. For the front teeth of man contribute in many ways to the formation of letter-sounds.

In some animals, however, the teeth, as already said, serve merely for the reduction of food. When, besides this, they serve as offensive and defensive weapons, they may either be formed into tusks, as for instance is the case in swine, or may be sharp-pointed and interlock with those of the opposite jaw, in which case the animal is said to be saw-toothed. The explanation of this latter arrangement is as follows. The strength of such an animal is in its teeth, and

[1] That is 'broad below and sharp above' (*H. A.* ii. 3. 537b 17).

these depend for their efficiency on their sharpness. In order, then, to prevent their getting blunted by mutual friction, such of them as serve for weapons fit into each other's interspaces, and are so kept in proper condition. No animal that has sharp interfitting teeth is at the same time furnished with tusks. For nature never makes anything superfluous or in vain. She gives, therefore, tusks to such animals as strike in fighting, and serrated teeth to such as bite. Sows, for instance, have no tusks, and accordingly sows bite instead of striking.

A general principle must here be noted, which will be found applicable not only in this instance but in many others that will occur later on. Nature allots each weapon, offensive and defensive alike, to those animals alone that can use it; or, if not to them alone, to them in a more marked degree; and she allots it in its most perfect state to those that can use it best; and this whether it be a sting, or a spur, or horns, or tusks, or what it may of a like kind.

Thus as males are stronger and more choleric than females, it is in males that such parts as those just mentioned are found, either exclusively, as in some species, or more fully developed, as in others. For though females are of course provided with such parts as are no less necessary to them than to males, the parts, for instance, which subserve nutrition, they have even these in an inferior degree, and the parts which answer no such necessary purpose they do
662a not possess at all. This explains why stags have horns, while does have none; why the horns of cows are different from those of bulls, and, similarly, the horns of ewes from those of rams. It explains also why the females are often without spurs in species where the males are provided with them, and accounts for similar facts relating to all other such parts.

All fishes have teeth of the serrated form, with the single exception of the fish known as the Scarus.[1] In many of them there are teeth even on the tongue and on the roof of

[1] The Scarus is doubtless the parrot-fish (*Scarus Cretensis*). This is, however, by no means the only exception to the general statement that all fishes have serrated dentition.

the mouth. The reason for this is that, living as they do in the water, they cannot but allow this fluid to pass into the mouth with the food. The fluid thus admitted they must necessarily discharge again without delay. For were they not to do so, but to retain it for a time while triturating the food, the water would run into their digestive cavities. Their teeth therefore are all sharp, being adapted only for cutting,[1] and are numerous and set in many parts,[2] that their abundance may serve in lieu of any grinding faculty, to mince the food into small bits. They are also curved, because these are almost the only weapons which fishes possess.

In all these offices of the teeth the mouth also takes its part; but besides these functions it is subservient to respiration, in all such animals as breathe and are cooled by external agency. For nature, as already said,[3] uses the parts which are common to all animals for many special purposes, and this[4] of her own accord. Thus the mouth has one universal function in all animals alike, namely its alimentary office; but in some, besides this, the special duty of serving as a weapon is attached to it; in others that of ministering to speech; and again in many, though not in all, the office of respiration. All these functions are thrown by nature upon one single organ, the construction of which she varies so as to suit the variations of office. Therefore it is that in some animals the mouth is contracted, while in others it is of wide dimensions. The contracted form belongs to such animals as use the mouth merely for nutritive, respiratory, and vocal purposes; whereas in such as use it as a means of defence it has

[1] Reading διαίρεσιν μόνον, καί (P).

[2] The mouth in many fishes, e.g. the pike, is beset with a countless number of sharp teeth which project from all parts of the internal surface. The object of this is not so much the comminution of the food, as A. supposes, as to enable the fish to retain hold of its slippery prey. Similarly the recurved form of the teeth, noticeable in many predatory species, serves to prevent the prey when once in the mouth from escaping, the points being all directed towards the oesophagus.

[3] Namely, at ii. 16. 658b 35, when speaking of the elephant's trunk. Similar statements are made (iv. 10. 688a 24, and 690a 2) concerning the female mammae, and the tails of animals.

[4] i. e. not of necessity.

a wide gape. This is its invariable form in such animals as are saw-toothed. For seeing that their mode of warfare consists in biting, it is advantageous to them that their mouth shall have a wide opening; for the wider it opens, the greater will be the extent of the bite, and the more numerous will be the teeth called into play.

What has just been said applies to fishes as well as to other animals; and thus in such of them as are carnivorous, and made for biting, the mouth has a wide gape; whereas in the rest it is small, being placed at the extremity of a tapering snout. For this form is suited for their purposes, while the other would be useless.

In birds the mouth consists of what is called the beak, which in them is a substitute for lips and teeth. This beak presents variations in harmony with the functions and
662b protective purposes which it serves. Thus in those birds that are called Crooked-clawed[1] it is invariably hooked, inasmuch as these birds are carnivorous, and eat no kind of vegetable food whatsoever. For this form renders it serviceable to them in obtaining the mastery over their prey, and is better suited for deeds of violence than any other. Moreover, as their weapons of offence consist of this beak and of their claws, these latter also are more crooked in them than in the generality of birds. Similarly in each other kind of bird the beak is suited to the mode of life. Thus, in woodpeckers[2] it is hard and strong, as also in crows and birds of crow-like habit, while in the smaller birds it is delicate, so as to be of use in collecting seeds and picking up minute animals. In such birds, again, as eat herbage, and such as live about marshes—those, for example, that swim and have webbed feet—the bill is broad, or adapted in some other way to the mode of life. For a broad bill enables a bird to dig into the ground with ease, just as, among quadrupeds, does the broad snout of the pig, an animal which, like the birds in question, lives

[1] i. e. the Raptores.

[2] The example is well chosen. For in woodpeckers, especially in the larger species, the beak acquires the density of ivory (cf. Owen, *Vert.* ii. 146). In the raven also, which is the bird usually meant by A. when he speaks of crows, the beak is hard and strong.

on roots. Moreover, in these root-eating birds and in some others of like habits of life, the tips of the bill end in hard points, which gives them additional facility in dealing with herbaceous food.

The several parts which are set on the head have now, pretty nearly all, been considered. In man, however, the part which lies between the head and the neck is called the face, this name (*prosōpon*) being, it would seem, derived from the function of the part. For as man is the only animal that stands erect, he is also the only one that looks directly in front (*prosō*); and the only one whose voice is emitted in that direction.

2 We have now to treat of horns; for these also, when present, are appendages of the head. They exist in none but viviparous animals; though in some ovipara certain parts are metaphorically spoken of as horns, in virtue of a certain resemblance.[1] To none of such parts, however, does the proper office of a horn belong; for they are never used, as are the horns of vivipara, for purposes which require strength, whether it be in self-protection or in offensive strife. So also no polydactylous animal[2] is furnished with horns. For horns are defensive weapons, and these polydactylous animals possess other means of security. For to some of them nature has given claws, to others teeth suited for combat, and to the rest some other adequate defensive appliance. There are horns, however, in most of the cloven-hoofed animals, and in some[3] of those that have 663a
a solid hoof, serving them as an offensive weapon, and in some cases also as a defensive one. There are horns

[1] For instance, in some male fishes, lizards, and many beetles, where the horns are not weapons but mere ornaments. So A. calls the antennae of Crustacea horns (*H. A.* iv. 2. 526^{a} 6). He alludes, however, more especially to the Egyptian snake (*H. A.* ii. 1. 500^{a} 3): 'Thus the Egyptians speak of the snakes about Thebes as horned, because they have a kind of projection which as it were simulates a horn.' This is a reference to Herodot. ii. 74, and the snake in question was doubtless the Cerastes of Egypt.

[2] Under Polydactyla are included Carnivora, Rodentia, Insectivora, Cheiroptera, as well as man, apes, and elephants; in fact all Mammalia known to A. excepting Ruminantia, Solidungula, and Cetacea.

[3] Meaning the Indian Ass. Cf. 663^{a} 20 note.

also in all animals that have not been provided by nature with some other means of security; such means, for instance, as speed, which has been given to horses; or great size, as in camels; for excessive bulk, such as has been given to these animals, and in a still greater measure to elephants, is sufficient in itself to protect an animal from being destroyed by others. Other animals again are protected by the possession of tusks; and among these are the swine, though they have a cloven hoof.[1]

All animals again, whose horns are but useless appendages, have been provided by nature with some additional means of security. Thus deer are endowed with speed; for the large size and great branching of their horns makes these a source of detriment rather than of profit to their possessors.[2] Similarly endowed are the Bubalus[3] and gazelle; for though these animals will stand up against some enemies and defend themselves with their horns, yet they run away from such as are fierce and pugnacious. The Bonasus[4] again, whose horns curve inwards towards each other,[5] is provided with a means of protection in the discharge of its excrement; and of this it avails itself when

[1] And therefore, he implies, might be expected to have horns, like most cloven-hoofed animals. Read διχαλὸν ὄν.

[2] It is somewhat astounding to find so determined a teleologist suddenly declaring that antlers are not merely useless but actually injurious to stags. A modern writer, however (Bailly, *Sur l'usage des cornes*, *Ann. d. Sc. Nat.* ii. 371), has come to the same conclusion: 'Quant aux bois du cerf, du renne, de l'élan, on sait qu'ils sont plus nuisibles qu'utiles.' The horns are, however, not so utterly useless as is here supposed, the upper antlers serving in defence, the brow antlers in attack (*Desc. of Man*, ii. 253). Still, as Darwin points out, the large branching horns do present a difficulty. For a straight point would inflict a much more serious wound than several diverging ones. Their great size and branching serve, however, as ornaments, and so give an advantage in the sexual struggle.

[3] The Bubalus must not be confounded with the Buffalo (*Bubalus*), which was known to A. as the wild ox of the Arachotae (*H. A.* i. 2. 499a 4). It is probably an Antelope, perhaps the Bubaline Antelope of N. Africa.

[4] The Bonasus (*H. A.* ix. 45) is universally admitted to be the European bison, which in the present day is almost extinct, existing only in Lithuania and in the Caucasus, but which in ancient times abounded in the forests of Europe generally. A. speaks of it (*H. A.* ii. 1. 500a 1) as living in his days in Paeonia and Medica, i. e. North Macedonia.

[5] And are therefore of no use as weapons.

frightened. There are some other animals besides the Bonasus that have a similar mode of defence. In no case, however, does nature ever give more than one adequate means of protection to one and the same animal.

Most of the animals that have horns are cloven-hoofed; but the Indian ass, as they call it, is also reported to be horned, though its hoof is solid.[1]

Again as the body, so far as regards its organs of motion, consists of two distinct parts, the right and the left, so also and for like reasons the horns of animals are, in the great majority of cases, two in number. Still there are some that have but a single horn; the Oryx,[2] for instance, and the so-called Indian ass; in the former of which the hoof is cloven, while in the latter it is solid. In such animals the horn is set in the centre of the head; for as the middle belongs equally to both extremes, this arrangement is the one that comes nearest to each side having its own horn.

Again, it would appear consistent with reason that the single horn should go with the solid rather than with the cloven hoof. For hoof, whether solid or cloven, is of the same nature as horn; so that the two naturally undergo division simultaneously and in the same animals. Again, since the division of the cloven hoof depends on deficiency of material, it is but rationally consistent, that nature, when she gave an animal an excess of material for the hoofs, which thus became solid, should have taken away something from the upper parts and so made the animal to have but one horn.

Rightly too did she act when she chose the head whereon to set the horns; and Æsop's Momus[3] is beside the mark,

[1] The account of the Indian Ass with a solid hoof, and a single horn, was taken by A. from Ctesias, who apparently did not profess himself to have seen more of the animal than its astragalus. It has been plausibly conjectured that the Indian Rhinoceros (*R. unicornis*) is the animal meant. For, though this animal has three toes, they are so indistinctly separated, that the real character of the foot might easily escape a casual observer, to whom the animal would, moreover, probably not give much leisure for observation.

[2] Probably the Leucoryx of N. Africa.

[3] The fable of Momus, the critic God, is alluded to by Lucian (*Nigrinus*, 32), and told in full by Babrius (Sir C. Lewes's ed. 59). Their account of the criticism on the bull's structure is not quite the

when he finds fault with the bull for not having its horns upon its shoulders. For from this position, says he, they would have delivered their blow with the greatest force,
663b whereas on the head they occupy the weakest part of the whole body. Momus was but dull-sighted in making this hostile criticism. For had the horns been set on the shoulders, or had they been set on any other part than they are, the encumbrance of their weight would have been increased, not only without any compensating gain whatsoever, but with the disadvantage of impeding many bodily operations. For the point whence the blows could be delivered with the greatest force was not the only matter to be considered, but the point also whence they could be delivered with the widest range. But as the bull has no hands and cannot possibly have its horns on its feet or on its knees, where they would prevent flexion, there remains no other site for them but the head; and this therefore they necessarily occupy. In this position, moreover, they are much less in the way[1] of the movements of the body than they would be elsewhere.

Deer are the only animals in which the horns are solid throughout, and are also the only animals that cast them. This casting is not simply advantageous to the deer from the increased lightness which it produces, but, seeing how heavy the horns are, is a matter of actual necessity.

In all other animals the horns are hollow for a certain distance, and the end alone is solid, this being the part of use in a blow. At the same time, to prevent even the hollow part from being weak, the horn, though it grows out[2] of the skin, has a solid piece from the bones fitted into its cavity. For this arrangement is not only that which makes the horns of the greatest service in fighting, but that

same as Aristotle's. Momus objects that the horns are so placed as to be in the way of the animal's sight when it has its head down to attack its foe.

[1] ἀνεμπόδιστα, in spite of its form, is here supposed to be used in an active sense on the authority of Bonitz (56a 6) and of Liddell and Scott.

[2] Omitting οὐ before πέφυκεν (EPYZ), cf. *H. A.* ii. 1. 500a 8. For εἶναι read ἐστίν (Platt).

which causes them to be as little of an impediment as possible in the other actions of life.

Such then are the reasons for which horns exist; and such the reasons why they are present in some animals, absent from others.

Let us now consider the character of the material nature whose necessary results have been made available by rational nature for a final cause.

In the first place, then, the larger the bulk of animals, the greater is the proportion of corporeal and earthy matter which they contain. Thus no very small animal is known to have horns, the smallest horned animal that we are acquainted with being the gazelle. But in all our speculations concerning nature, what we have to consider is the general rule; for that is natural which applies either universally or generally. And thus when we say that the largest animals have most earthy matter, we say so because such is the general rule. Now this earthy matter is used in the animal body to form bone. But in the larger animals there is an excess of it, and this excess is turned by nature to useful account, being converted into weapons of defence. Part of it necessarily flows to the upper portion of the body, and this is allotted by her in some cases to the formation of tusks and teeth, in others to the formation of horns. Thus it is that no animal that has horns has also front teeth
in both jaws, those in the upper jaw being deficient.[1] For 664a
nature by subtracting from the teeth adds to the horns; the nutriment which in most animals goes to the former being here spent on the augmentation of the latter. Does, it is true, have no horns and yet are equally deficient with the males as regards the teeth. The reason, however, for this is that they, as much as the males, are naturally horn-bearing animals; but they have been stripped of their

[1] 'The inverse relationship between the development of teeth and horns, exemplified by the total absence of canines in the ruminants with persistent frontal weapons, by their first appearance in the periodically hornless deer, and by their larger size in the absolutely hornless musks, is further illustrated by the presence not only of canines but of a pair of laniariform incisors in the upper jaw of Camelidae' (Owen *Vert.* iii. 348).

horns, because these would not only be useless to them but actually baneful; whereas the greater strength of the males causes these organs, though[1] equally useless, to be less of an impediment. In other animals, where this material is not secreted from the body in the shape of horns, it is used to increase the size of the teeth; in some cases of all the teeth, in others merely of the tusks, which thus become so long as to resemble horns projecting from the jaws.

So much, then, of the parts which appertain to the head.

Below the head lies the neck, in such animals as have **3**
one. This is the case with those only that have the parts to which a neck is subservient. These parts are the larynx[2] and what is called the oesophagus. Of these the former, or larynx, exists for the sake of respiration, being the instrument by which such animals as breathe inhale and discharge the air. Therefore it is that, when there is no lung, there is also no neck. Of this condition the Fishes are an example. The other part, or oesophagus, is the channel through which food is conveyed to the stomach; so that all animals that are without a neck are also without a distinct oesophagus. Such a part is in fact not required of necessity for nutritive purposes; for it has no action whatsoever on the food. Indeed there is nothing to prevent the stomach from being placed directly after the mouth. This, however, is quite impossible in the case of the lung. For there must be some sort of tube common to the two divisions of the lung, by which—it being bipartite—the breath may be apportioned to their respective bronchi, and thence pass into the air-pipes; and such an arrangement

[1] In some cases.

[2] The word here rendered *larynx* is in the Greek *pharynx*. It is quite clear, however, that the part which is made of cartilage, serves for vocal and respiratory purposes, lies in front of the oesophagus, &c., can only be what we call larynx. Yet the word *larynx* was known to A., and occasionally used by him as by us. It would seem that the two words *pharynx* and *larynx* had not in his day been clearly differentiated from each other, but were used indifferently for one and the same part (*H. A.* iv. 9. 535a 29, 32, and Aristophanes, *Frogs*, 571–5), namely the larynx. What we call *pharynx* had for A. no distinct name, being nothing more than the first part of the oesophagus; which latter he says, later on in this chapter, is directly continuous with the mouth.

will be the best for giving perfection to inspiration and expiration. The organ then concerned in respiration must of necessity be of some length ; and this, again, necessitates there being an oesophagus to unite mouth and stomach.[1] This oesophagus is of a flesh-like character, and yet admits of extension like a sinew.[2] This latter property is given to it, that it may stretch when food is introduced ; while the flesh-like character is intended to make it soft and yielding, and to prevent it from being rasped by particles as they pass downwards, and so suffering damage. On the other hand, the windpipe and the so-called larynx are constructed out of a cartilaginous substance. For they have to serve 664b not only for respiration, but also for vocal purposes ; and an instrument that is to produce sounds must necessarily be not only smooth but firm. The windpipe lies in front of the oesophagus, although this position causes it to be some hindrance to the latter in the act of deglutition. For if a morsel of food, fluid or solid, slips into it by accident, choking and much distress and violent fits of coughing ensue. This must be a matter of astonishment to any of those who assert that it is by the windpipe that an animal imbibes fluid.[3] For the consequences just mentioned occur invariably, whenever a particle of food slips in, and are quite obvious. Indeed on many grounds it is ridiculous to say that this is the channel through which animals imbibe fluid. For there is no passage leading from the lung to the stomach, such as the oesophagus which we see leading thither from the mouth. Moreover, when any cause produces sickness and vomiting, it is plain enough whence the fluid is discharged. It is manifest also that fluid, when swallowed, does not pass directly into the

[1] It would probably be truer to say that there is a long trachea in order that there may be a long neck, so as to facilitate the motions of the head, than to say, as A. does, that there must be a long neck, in order to provide space for a long trachea. Still the length of the trachea is not without use ; for the air in its passage down the long canal is filtered of its dust, moistened, and warmed. In some animals the trachea is still further lengthened by being formed into a coil.

[2] Cf. iii. 4. 666b 13 note.

[3] Alluding to Plato (*Timaeus*, 70 C). Hippocrates mentions and attacks this same strange notion (*De Morbis*, iv. 30).

bladder and collect there, but goes first into the stomach. For, when red wine is taken, the dejections of the stomach are seen to be coloured by its dregs; and such discoloration has been even seen on many occasions inside the stomach itself, in cases where there have been wounds opening into that organ. However, it is perhaps silly to be minutely particular in dealing with silly statements such as this.

The windpipe then, owing to its position in front of the oesophagus, is exposed, as we have said, to annoyance from the food. To obviate this, however, nature has contrived the epiglottis. This part is not found in all sanguineous animals,[1] but only in such of them as have a lung; nor in all of these, but only in such as at the same time have their skin covered with hairs, and not either with scaly plates or with feathers. In such scaly and feathered animals there is no epiglottis, but its office is supplied by the larynx,[2] which closes and opens, just as in the other case the epiglottis falls down and rises up; rising up during the ingress or egress of breath, and falling down during the ingestion of food, so as to prevent any particle from slipping into the windpipe. Should there be the slightest want of accuracy in this movement, or should an inspiration be made during the ingestion of food, choking and coughing ensue, as already has been noticed. So admirably contrived, however, is the movement both of the epiglottis and of the tongue, that, while the food is being ground to a pulp in the mouth, the tongue very rarely gets caught between the teeth; and, while the food is passing over the epiglottis, seldom does a particle of it slip into the windpipe.

665a The animals which have been mentioned as having no epiglottis owe this deficiency to the dryness of their flesh and to the hardness of their skin. For an epiglottis made of such materials would not admit of easy motion. It would, indeed, take a longer time to shut down an epiglottis made of the peculiar flesh of these animals, and shaped

[1] For ζῳοτοκοῦντα, which is obviously wrong, read ζῷα τὰ ἔναιμα.

[2] Mammals alone have an epiglottis. In other vertebrates the opening into the larynx and trachea is closed simply by constrictor muscles.

like that of those with hairy skins, than to bring the edges of the windpipe itself into contact with each other.

Thus much then as to the reason why some animals have an epiglottis while others have none, and thus much also as to its use. It is a contrivance of nature to remedy the vicious position of the windpipe in front of the oesophagus. That position is the result of necessity. For it is in the front and centre of the body that the heart is situated, in which we say is the principle of life and the source of all motion and sensation. (For sensation and motion are exercised in the direction which we term forwards, and it is on this very relation that the distinction of before and behind is founded.) But where the heart is, there and surrounding it is the lung. Now inspiration, which occurs for the sake of the lung and for the sake of the principle which has its seat in the heart, is effected through the windpipe. Since then the heart must of necessity lie in the very front place of all, it follows that the larynx also and the windpipe must of necessity lie in front of the oesophagus. For they lead to the lung and heart,[1] whereas the oesophagus leads to the stomach. And it is a universal law that, as regards above and below, front and back, right and left, the nobler and more honourable part invariably is placed uppermost, in front, and on the right, rather than in the opposite positions, unless some more important object stands in the way.

[1] It is not necessary to infer with Frantzius from this passage, that A. thought that the windpipe communicated directly with the heart. For he supposed that air could pass without any such direct channel, as the following passages show. 'When the windpipe reaches the lung, it divides and subdivides, each division producing smaller and smaller branches, till the whole lung is permeated by them' (*H. A.* i. 16. 495b 8). 'There are also ducts (i. e. *the pulmonary blood-vessels*) which lead from the heart to the lung; and these also divide and subdivide, their branches accompanying the branches from the windpipe. But there is no communication between the two (οὐδεὶς δ' ἐστὶ κοινὸς πόρος). Notwithstanding this, however, air can pass from the former (i. e. *the bronchial tubes*) into the latter (i. e. *the pulmonary vessels*), owing to the close contact in which the two lie (διὰ τὴν σύναψιν), and be transmitted to the heart' (*H. A.* i. 17. 496a 28). This passage shows that A. not only had a fair knowledge of the anatomy of the lung, but also believed the air to pass from the air-passages into the blood-vessels through their unbroken walls, just as we hold the oxygen to do.

We have now dealt with the neck, the oesophagus, and 4
the windpipe, and have next to treat of the viscera. These are peculiar to sanguineous animals, some of which have all of them, others only a part, while no bloodless animals have any at all.[1] Democritus then seems to have been mistaken in the notion he formed of the viscera, if, that is to say, he fancied that the reason why none were discoverable in bloodless animals was that these animals were too small to allow them to be seen. For, in sanguineous animals, both heart and liver are visible enough when the body is only just formed, and while it is still extremely small. For these parts are to be seen in the egg sometimes as early as the third day, being then no bigger than
665b a point;[2] and are visible also in aborted embryos, while still excessively minute. Moreover, as the external organs are not precisely alike in all animals, but each creature is provided with such as are suited to its special mode of life and motion, so is it with the internal parts, these also differing in different animals. Viscera, then, are peculiar to sanguineous animals; and therefore are each and all formed from sanguineous material, as is plainly to be seen in the new-born young of these animals. For in such the viscera are more sanguineous, and of greater bulk in proportion to the body, than at any later period of life, it being in the earliest stage[3] of formation that the nature of the material and its abundance are most conspicuous. There is a heart, then, in all sanguineous animals, and

[1] A. limits the term viscera to such internal parts as are so coloured as to resemble blood, of which in fact he supposes them to be formed (iii. 4. 665b 6; iii. 10. 673b 1). As the bloodless animals have merely a fluid analogous to blood, so they can only have parts analogous to viscera.

[2] Cf. *H. A.* vi. 3. 561a 11, where it is said that the heart in the bird's egg at its first appearance looks like a bloody spot, and palpitates as though endowed with life; a description which is the origin of the *punctum saliens* of later writers.

[3] The liver in the mature foetus forms $\frac{1}{10}$th of the whole body; in the adult it forms only $\frac{1}{37}$th. The heart also is larger proportionately to the whole body in the young embryo ($\frac{1}{30}$th) than in the mature foetus ($\frac{1}{120}$th), and in the foetus than in adult man ($\frac{1}{170}$th). In infancy again the lungs are of a brightish colour, 'which might be compared to blood froth; but as life advances they become darker, mottled with spots, patches, &c.' Cf. Quain's *Anat.* 1145.

the reason for this has already been given.[1] For that sanguineous animals must necessarily have blood is self-evident. And, as the blood is fluid, it is also a matter of necessity that there shall be a receptacle for it; and it is apparently to meet this requirement that nature has devised the blood-vessels. These, again, must necessarily have one primary source. For it is preferable that there shall be one such, when possible, rather than several. This primary source of the vessels is the heart. For the vessels manifestly issue from it and do not go through it.[2] Moreover, being as it is homogeneous, it has the character of a blood-vessel. Again its position is that of a primary or dominating part. For nature, when no other more important purpose stands in her way, places the more honourable part in the more honourable position; and the heart lies about the centre of the body, but rather in its upper than its lower half, and also more in front than behind. This is most evident in the case of man, but even in other animals there is a tendency in the heart to assume a similar position, in the centre of the necessary part of the body, that is to say of the part which terminates in the vent for excrement. For the limbs vary in position in different animals, and are not to be counted with the parts which are necessary for life. For life can be maintained even when they are removed; while it is self-evident that the addition of them to an animal is not destructive of it.

There are some[3] who say that the vessels commence in the head. In this they are clearly mistaken. For in the first place, according to their representation, there would be many sources for the vessels, and these scattered; and secondly, these sources would be in a region that is manifestly cold, as is shown by its intolerance of chill, whereas the region of the heart is as manifestly hot. Again, as already said, the vessels continue their course through the other viscera, but no vessel spreads through the heart.[4]

[1] Cf. iii. 3. 665a 12.

[2] See note 4.

[3] Elsewhere (*H. A.* iii. 3. 513a 10) A. says that not only some but all his predecessors held this opinion.

[4] The terms *διέχουσι* and *διατείνουσι*, used several times in describing the relation of the blood-vessels to the viscera, present much difficulty.

From this it is quite evident that the heart is a part of the vessels and their origin ; and for this it is well suited by its structure. For its central part consists of a dense and hollow substance, and is moreover full of blood, as though
666a the vessels took thence their origin. It is hollow to serve for the reception of the blood, while its wall is dense, that it may serve to protect the source of heat. For here, and here alone in all the viscera and indeed in all the body, there is blood without blood-vessels, the blood elsewhere being always contained within vessels. Nor is this but consistent with reason. For the blood is conveyed into the vessels from the heart, but none passes into the heart from without.[1] For in itself it constitutes the origin and fountain, or primary receptacle, of the blood. It is, however, from

The natural interpretation of διέχουσι would be that the vessels traverse the viscera and pass on to some other part; and in the case of the liver such an interpretation is neither impossible nor improbable. For A. may have well supposed that the Hepatic vein after giving numerous small branches to the liver (*H. A.* iii. 4. 514a 33) passed on as the *vena portae* to the intestinal parts ; and indeed it is difficult to see what other explanation A. could find for the *vena portae*; if no vessel could originate in the liver and the course of all vessels was to the periphery.

But in the case of the other viscera such an interpretation is impossible ; for A. distinctly states that all the blood brought to kidneys and spleen is used up in the substance of those viscera (iii. 9. 671b 13 ; *H. A.* i. 17. 497a 9 ; iii. 4. 514b 5), the viscera being indeed mainly intended to provide means of disposing of the surplus blood.

It seems therefore impossible to give any other meaning to διέχουσι, at any rate in the case of other viscera than the liver, than 'spread through the substance', making it equivalent to διατείνουσι as indeed it apparently is at iii. 4. 665b 32. Similarly when it is said that no blood-vessel διατείνει the heart, it must be understood as meaning that no nutrient vessels are distributed through its substance (the coronary vessels being overlooked), this organ being nourished (ii. 1. 647b 6) by the blood in its own cavities. A. appears to have used διέχουσι ambiguously, applying it to the liver in a different sense from that in which he applies it to the other viscera and the heart.

[1] These words must not be interpreted too strictly ; for, though of course A. holds the main current of blood to run from the heart outwards, he admits some flow in the opposite direction. Indeed, without this the heart could have no material for elaboration. The food, absorbed from the stomach as vapour, is, he says, converted into fluid in the blood-vessels and passes on as such to the heart (*De S. et V.* 3. 456b 3). The blood-vessels that go to the head are likened by him to a narrow strait in which the current changes to and fro (*De S. et V.* 3. 456b 20) ; and the heart is distinctly stated (*De S. et V.* 3. 458b 18) to receive blood both from the great vessel and from the aorta.

dissections and from observations on the process of development that the truth of these statements receives its clearest demonstration. For the heart is the first of all the parts to be formed; and no sooner is it formed than it contains blood. Moreover, the motions of pain and pleasure, and generally of all sensation, plainly have their source in the heart, and find in it their ultimate termination. This, indeed, reason would lead us to expect. For the source must, whenever possible, be one; and, of all places, the best suited for a source is the centre. For the centre is one, and is equally or almost equally within reach of every part. Again, as neither the blood itself, nor yet any part which is bloodless, is endowed with sensation, it is plain that that part which first has blood, and which holds it as it were in a receptacle, must be the primary source of sensation. And that this part is the heart is not only a rational inference, but is also evident to the senses. For no sooner is the embryo formed, than its heart is seen in motion as though it were a living creature, and this before any of the other parts, it being, as thus shown, the starting-point of their nature in all animals that have blood. A further evidence of the truth of what has been stated is the fact that no sanguineous animal is without a heart. For the primary source of blood must of necessity be present in them all. It is true that sanguineous animals not only have a heart but also invariably have a liver. But no one could ever deem the liver to be the primary organ either of the whole body or of the blood. For the position in which it is placed is far from being that of a primary or dominating part; and, moreover, in the most perfectly finished animals there is another part, the spleen, which as it were counterbalances it. Still further, the liver contains no spacious receptacle in its substance, as does the heart; but its blood is in a vessel as in all the other viscera. The vessel, moreover, extends through it, and no vessel whatsoever originates in it; for it is from the heart that all the vessels take their rise. Since then one or other of these two parts must be the central source, and since it is not the liver which is such, it follows of necessity that it is the heart which is the source of the blood, as also the primary organ in

other respects. For the definitive characteristic of an animal is the possession of sensation; and the first sensory part is that which first has blood; that is to say is the heart, which
666b is the source of blood and the first of the parts to contain it.

The apex of the heart is pointed and more solid than the rest of the organ. It lies against the breast, and entirely in the anterior part of the body, in order to prevent that region from getting chilled. For in all animals there is comparatively little flesh over the breast, whereas there is a more abundant covering of that substance on the posterior surface, so that the heat has in the back a sufficient amount of protection. In all animals but man the heart is placed in the centre of the pectoral region; but in man [1] it inclines a little towards the left, so that it may counterbalance the chilliness of that side. For the left side is colder in man, as compared with the right, than in any other animal. It has been stated in an earlier treatise [2] that even in fishes the heart holds the same position as in other animals; and the reason has been given why it appears not to do so. The apex of the heart, it is true, is in them turned towards the head, but this in fishes is the front aspect, for it is the direction in which their motion occurs.[3]

The heart again is abundantly supplied with sinews,[4] as

[1] It is not quite true that man is the only animal in which the heart inclines to the left. A like obliquity exists in the higher quadrumana (Cuvier, *Anat. Comp.* iv. 197), and in the mole.

[2] *De Resp.* 16. 478b 3.

[3] By the apex of the heart of fishes A. plainly means the point at the anterior extremity of the organ, where the *bulbus arteriosus* gives off the branchial artery. This, however, has no anatomical correspondence with the apex of the heart of other vertebrates. A. makes a similar statement as to the position of the fish's heart elsewhere (*H. A.* ii. 17. 507a 3; *De Resp.* 16. 478b 2), and accounts for it by saying that the head in other animals is moved in a vertical plane, from above downwards, whereas in fishes it has no such motion. Forwards then in a fish is in the line from tail to mouth, while in other animals it is in the line from above downwards, that is, from the back to the sternum.

[4] Under νεῦρα A. included (iii. 4. 666b 14 note) tendons, sinews, ligaments, and all other fibrous parts; with which, moreover, were confounded any nerves which may have been noticed, without recognition of their special nature, in the course of dissection; and this accounts for the statement (*H. A.* iii. 5. 515b 20) that numbness is never produced in a part where there are no νεῦρα. The active part in muscular contraction was taken not by the red tissue but by the νεῦρα, that is by the

might reasonably be expected. For the motions of the body commence from the heart, and are brought about by traction and relaxation. The heart therefore, which, as already said,[1] is as it were a living creature inside its possessor, requires some such subservient and strengthening parts.

In no animals does the heart contain a bone, certainly in none of those that we have ourselves inspected, with the exception of the horse and a certain kind of ox. In these exceptional cases the heart, owing to its large bulk, is provided with a bone as a support; just as the bones serve as supports for the body generally.[2]

In animals of great size the heart has three cavities;[3] in smaller animals it has two; and in all has at least one, for, as already stated,[4] there must be some place in the heart to serve as a receptacle for the first blood; which, as has been mentioned more than once, is formed in this organ. But inasmuch[5] as the main blood-vessels[6] are two in

tendinous fibres. The blood-vessels as they advanced became smaller and smaller, until at last their calibre was insufficient for the passage of blood, and the red muscular tissue consisted of a mass of small vessels thus choked up with inspissated blood (iii. 5. 668^b 1). The vessels themselves, however, were continued as solid fibres (*H. A.* iii. 5. 515^a 31) to form by their aggregation the tendon (*νεῦρον*), and it was to the shortening and widening of these tendinous fibres, endowed with transverse extensibility (*H. A.* iii. 5. 515^b 15), that muscular action was due, the red tissue being completely inactive, and serving merely as the medium of Touch.

[1] iii. 4. 666^a 22.

[2] Cf. *H. A.* ii. 15. 506^a 8. It is not uncommon to find in large mammalia, especially in Pachyderms and Ruminants, a cruciform ossification in the heart, below the origin of the aorta. In the ox this is a normal formation, as also in the stag. But in Pachyderms, or at any rate in the horse, it is only found in old individuals, and appears to be the result of pathological degeneration.

[3] Commentators differ widely as to these three cavities, nor do the several passages relating to them admit of any thoroughly consistent and satisfactory interpretation. I am, however, strongly of opinion that the three are the two ventricles and the left auricle (see ch. 5. 667^b 16 n.). This view was promulgated by me in a lengthy note to my former translation. I found afterwards that Huxley had already come to the same conclusion, and had set it forth in an elaborate article in *Nature* (Nov. 6, 1869); republished in *Science and Nature* (p. 180).

[4] Cf. 666^a 7.

[5] Put a full stop after *εἰρήκαμεν*. Read *Διὰ δὲ τό* (ESUYZ) and put *ἑκατέρας* . . . . *ἐροῦμεν* in brackets with omission of *γάρ*.

[6] See first note to next chapter.

number, namely the so-called great vessel and the aorta, each of which is the origin of other vessels; inasmuch, moreover, as these two vessels present differences, hereafter to be discussed,[1] when compared with each other, it is of advantage that they also shall themselves have distinct origins. This advantage will be obtained if each side have its own blood, and the blood of one side be kept separate from that of the other. For this reason the heart, whenever it is possible, has two receptacles. And this possibility exists in the case of large animals, for in them the heart, as the body generally, is of large size. Again it is still better that there shall be three cavities, so that the middle and odd one may serve as a centre common to both sides. But this requires the heart to be of greater magnitude, so that it is only in the largest hearts that there are three cavities.

667a Of these three cavities it is the right that has the most abundant[2] and the hottest blood, and this explains why the limbs also on the right side of the body are warmer than those on the left. The left cavity has the least blood of all, and the coldest; while in the middle cavity the blood, as regards quantity and heat, is intermediate to the other two, being however of purer quality than either. For it behoves the supreme part to be as tranquil as possible, and this tranquillity can be ensured by the blood being pure, and of moderate amount and warmth.

In the heart of animals there is also a kind of joint-like division,[3] something like the sutures of the skull. This is not, however, attributable to the heart being formed by the union of several parts into a compound whole, but is rather, as already said, the result of a joint-like division. These

[1] Cf. iii. 5. 667^b 15.

[2] In an animal, especially one killed by strangulation, as recommended by A. (*H. A.* iii. 3. 513^a 13), the right side of the heart and the vessels connected with it would be found gorged with dark blood and contrasting strongly with the almost empty left side and vessels. It is doubtless this that makes A. say that the blood is more abundant, less pure, and denser (*H. A.* i. 17. 496^b 10) on the right side than on the left.

[3] The allusion is to the transverse and longitudinal grooves which mark out on the surface the limits of auricles and ventricles. A. is quite right in saying that the heart is not formed by the union of distinct parts into a whole. It is at first a body with a single cavity, which is converted into several by the after-development of internal septa.

jointings are most distinct in animals of keen sensibility, and less so in those that are of duller feeling, in swine for instance. Different hearts differ also from each other in their sizes, and in their degrees of firmness; and these differences somehow extend their influence to the temperaments of the animals. For in animals of low sensibility the heart is hard and dense in texture, while it is softer in such as are endowed with keener feeling. So also when the heart is of large size the animal is timorous, while it is more courageous if the organ be smaller and of moderate bulk. For in the former the bodily affection which results from terror already pre-exists; for the bulk of the heart is out of all proportion to the animal's heat, which being small is reduced to insignificance in the large space, and thus the blood is made colder than it would otherwise be.

The heart is of large size[1] in the hare, the deer, the mouse, the hyena, the ass, the leopard, the marten, and in pretty nearly all other animals that either are manifestly timorous, or betray their cowardice by their spitefulness.

What has been said of the heart as a whole is no less true of its cavities and of the blood-vessels; these also if of large size being cold. For just as a fire of equal size gives less heat in a large room than in a small one, so also does the heat in a large cavity or a large blood-vessel, that is in a large receptacle, have less effect than in a small one. Moreover, all hot bodies are cooled by motions external to themselves,[2] and the more spacious the cavities and vessels are, the greater the amount of spirit they contain, and the more potent its action. Thus it is that no animal that has large cavities in its heart, or large blood-vessels, is ever fat, the vessels being indistinct and the cavities small in all or most fat animals.

The heart again is the only one of the viscera, and indeed the only part of the body, that is unable to tolerate any serious affection.[3] This is but what might reasonably be

[1] The heart is very large in the hare, nearly twice as heavy in proportion to the body-weight, as in man. As regards the other animals I can give no accurate figures.

[2] Cf. iii. 6. 669b 3 note.

[3] Cf. iv. 2. 677b 4. (Daremberg (*Galen.* i. 401) represents A. as

expected. For, if the primary or dominant part be diseased, there is nothing from which the other parts which depend 667b upon it can derive succour. A proof that the heart is thus unable to tolerate any morbid affection is furnished by the fact that in no sacrificial victim has it ever been seen to be affected with those diseases that are observable in the other viscera. For the kidneys are frequently found to be full of stones, and growths, and small abscesses, as also are the liver, the lung, and more than all the spleen. There are also many other morbid conditions which are seen to occur in these parts, those which are least liable to such being the portion of the lung which is close to the windpipe, and the portion of the liver which lies about the junction with the great blood-vessel. This again admits of a rational explanation. For it is in these parts that the lung and liver are most closely in communion with the heart. On the other hand, when animals die not by sacrifice but from disease, and from affections such as are mentioned above, they are found on dissection to have morbid affections of the heart.

Thus much of the heart, its nature, and the end and cause of its existence in such animals as have it.

In due sequence we have next to discuss the blood- 5
vessels, that is to say the great vessel and the aorta.[1] For

saying in this passage that the heart is not liable to disease, or at any rate less liable than other organs ; just as Galen said that it was made of hard flesh which could not easily be injured. But in fact A. says nothing of the kind, but merely states what is fairly true, viz. that diseases of the heart are more certainly fatal, and less consistent with apparently good health, than diseases of other parts, so that when a victim, i.e. an animal supposed to be of sound health, is sacrificed, its heart is never found diseased, though such is frequently the case when an animal dies of a malady. What would A. have thought of the bull sacrificed by Caesar, which the soothsayers asserted to have no heart at all (Cicero, *De Div.* ii. 16) !

[1] The 'great vessel', as I interpret A.'s account, consists of the upper and lower Venae cavae, with the right auricle, considered by A., as by Galen and later anatomists, to be no part of the heart but merely the dilated junction of the two Venae cavae. This communicates with the largest cavity (*right ventricle*) by the wide auriculo-ventricular opening, and from this same cavity issues the pulmonary artery, regarded by A. in virtue of its connexion with the same cavity, its having a similarly thin wall, and being found after death (iii. 4. 667a 2 note) similarly gorged with dark blood, as a part of the 'great vessel', though separated from its main trunk by the interposition of the right ventricle,

it is into these two that the blood first passes when it quits the heart; and all the other vessels are but offshoots from them. Now that these vessels exist on account of the blood has already been stated. For every fluid requires a receptacle, and in the case of the blood the vessels are that receptacle. Let us now explain why these vessels are two, and why they spring from one single source, and extend throughout the whole body.

The reason, then, why these two vessels coalesce into one centre, and spring from one source, is that the sensory soul is in all animals actually one; and this one-ness of the sensory soul determines a corresponding one-ness of the part in which it primarily abides. In sanguineous animals this one-ness is not only actual but potential, whereas in some bloodless animals[1] it is only actual. Where, however, the sensory soul is lodged, there also and in the self-same place must necessarily be the source of heat; and, again, where this is there also must be the source of the blood, seeing that it thence derives its warmth and fluidity. Thus, then, in the oneness of the part in which is lodged the prime source of sensation and of heat is involved the oneness of the source in which the blood originates; and this,

this being the cavity referred to (*H. A.* iii. 3. 513b 4) as that ἐν ᾧ λιμνάζει τὸ αἷμα. The middle cavity from which the aorta proceeds is the left ventricle, and the smallest is the left auricle. All three cavities are connected with the lung, but in only one (*right ventricle*) is the connexion distinctly visible (*H. A.* iii. 3. 513a 36). Thus 'the great vessel' comprises all the vessels connected with the right side of the heart, and the aorta comprises all that are connected with the left, that is all the systemic arteries and the pulmonary veins, and each side has its distinct and completely separate blood (iii. 4. 666b 29), which is much more abundant, denser, and less pure (iii. 4. 667a 2 note) on the right side than on the left. Lastly, the opening by which the aorta communicates with the heart is much smaller (*H. A.* iii. 3. 513b 5) than that by which 'the great vessel' so communicates, i. e. the right auriculo-ventricular opening, not the aperture of the pulmonary artery, as stated by error in my former translation.

[1] Alluding to such Invertebrata as insects, myriapods, and annelids, which he frequently mentions as capable of living for a short time when cut into segments; which shows that each segment must have its own centre of vitality; the entire animal seemingly consisting of an aggregation of many animals, each with a certain individuality, which ordinarily is merged in the life of the aggregate, but is capable of asserting its existence when the segment is isolated; the only reason, in fact, why such an isolated segment does not live more than a short time, being that it has not got the necessary organs of nutrition.

again, explains why the blood-vessels have one common starting-point.

The vessels, again, are two, because the body of every sanguineous animal that is capable of locomotion [1] is bilateral; for in all such animals there is a distinguishable before and behind, a right and left, an above and below. Now as the front is more honourable and of higher supremacy than the hinder aspect, so also and in like degree is
668a the great vessel superior to the aorta. For the great vessel is placed in front, while the aorta is behind; the former again is plainly visible in all sanguineous animals, while the latter is in some indistinct and in some not discernible at all.

Lastly, the reason for the vessels being distributed throughout the entire body is that in them, or in parts analogous to them, is contained the blood, or the fluid which in bloodless animals takes the place of blood, and that the blood or analogous fluid is the material from which the whole body is made. Now as to the manner in which animals are nourished,[2] and as to the source from which

[1] As all the sanguineous animals, i. e. vertebrates, are capable of locomotion, these words might seem surplusage. But they are not so. For A. holds that the bilateral symmetry of animals belongs to them primarily in virtue of their locomotor organs; and that the symmetrical disposition of these determines an imperfect degree of bilateral symmetry in the organs of vegetative life.

[2] A.'s general notions on the subject of nutrition were much as follows:—

The food masticated in the mouth, but not otherwise altered (ii. 3. 650a 11), reaches the stomach, where it is concocted; the heat for this purpose, which is not common heat but a heat with special powers (ii. 6. 652a 10 note), being supplied by the liver and spleen, which are hot organs in close contiguity with the stomach (iii. 7. 670a 21). The solid and indigestible portion passes off by the lower bowel, but the fluid portion, which alone can be serviceable in nutrition (ii. 2. 647b 26), is absorbed by the blood-vessels of the stomach and intestine (iv. 4. 678a 10), over the surface of which they are spread like the roots of a plant (ii. 3. 650a 25). These blood-vessels open by very minute and invisible pores into the intestine, pores like those in jars of unbaked clay that let water filter through (*G. A.* ii. 6. 743a 9). The matter thus absorbed passes up to the heart in the form of vapour (*ἀναθυμιᾶται*), not as yet being blood, but only (ii. 4. 651a 17) an imperfect serum (*ἰχώρ*). In the heart and vessels (*De Somno*, 3. 456b 4) it undergoes a second concoction, these being the hottest parts of the body, and by this second concoction the serum is converted into blood (*H. A.* iii. 19. 521a 17), the ultimate food of all the organs. The amount of blood thus formed is extremely small, as compared with the original materials

they obtain nutriment and as to the way in which they absorb this from the stomach, these are matters which may be more suitably considered and explained in the treatise on Generation.[1] But inasmuch as the parts are, as already said, formed out of the blood, it is but rational that the flow of the blood should extend, as it does, throughout the whole of the body. For since each part is formed of blood, each must have blood about and in its substance.

To give an illustration of this. The water-courses in gardens are so constructed as to distribute water from one single source or fount into numerous channels, which divide and subdivide so as to convey it to all parts; and, again, in house-building stones are thrown down along the whole ground-plan of the foundation walls; because the garden-plants in the one case grow at the expense of the water, and the foundation walls in the other are built out of the stones. Now just after the same fashion has nature laid down channels for the conveyance of the blood throughout the whole body, because this blood is the material out of which the whole fabric is made. This becomes very evident in bodies that have undergone great emaciation. For in such there is nothing to be seen but the blood-vessels; just as when fig-leaves or vine-leaves or the like have dried up, there is nothing left of them but their vessels. The explanation of this is that the blood, or fluid which takes its

(*G. A.* i. 18. 725a 18). The blood when made passes from the heart by the vessels (arteries and veins alike), being mingled with air inhaled by the lungs and thence conveyed to the heart, and is carried to all parts of the body. Each organ selects from the common stock those materials which it requires. The nobler parts, such as the flesh and the organs of sense, take the choicer elements, while the inferior parts, as bones and sinews, are fed on the inferior elements or leavings (ὑπολείμματα) of the former (*G. A.* ii. 6. 744b 15). This nutrition of the parts goes on most actively at night (*De Somno*, 1. 454b 32).

Thus every part of the blood that can be turned to account is utilized; but such as from its quality is unfit for use, for instance any bitter substance, is excreted as bile, urine, sweat, etc., in company with the matter which results from the decay (σύντηξις) of the parts themselves.

Such surplus of nutritious matter as there may be, after all parts are satisfied, is either stored up in the body as fat or the like, or passes out to form hairs, scales, feathers, and other cutaneous appendages.

[1] *G. A.* ii. 4. 740a 21–b 12, 6. 743a 8 – 7. 746a 28.

place, is potentially body and flesh, or substance analogous to flesh. Now just as in irrigation the largest dykes are permanent, while the smallest are soon filled up with mud and disappear, again to become visible when the deposit of mud ceases; so also do the largest blood-vessels remain permanently open, while the smallest are converted actually into flesh, though potentially they are no whit less vessels than before.[1] This too explains why, so long as the flesh of an animal is in its integrity, blood will flow from any part of it whatsoever that is cut, though no vessel, however small, be visible in it. Yet there can be no blood, unless there be a blood-vessel. The vessels then are there, but are invisible owing to their being clogged up, just as the dykes for irrigation are invisible until they have been cleared of mud.

668b As the blood-vessels advance, they become gradually smaller and smaller, until at last their tubes are too fine to admit the blood. This fluid can therefore no longer find its way through them, though they still give passage to the humour which we call sweat; and especially so when the body is heated, and the mouths of the small vessels are dilated. Instances, indeed, are not unknown of persons who in consequence of a cachectic state have secreted sweat that resembled blood,[2] their body having become loose and flabby, and their blood watery, owing to the heat in the small vessels having been too scanty for its concoction. For, as was before said, every compound of earth and water—and both nutriment and blood are such—becomes thicker from concoction. The inability of the heat to effect concoction may be due either to its being absolutely small in amount, or to its being small in proportion to the quantity of food, when this has been taken in excess. This excess again may be of two kinds, either quantitative or qualitative; for all substances are not equally amenable to concoction.

The widest passages in the body are of all parts the most

[1] Cf. iii. 4. 666b 15 note.
[2] Instances of red-coloured sweat are not unknown. Cf. Todd, *Cycl. An. and Phys.* iv. 844.

liable to haemorrhage ; so that bleeding occurs not infrequently from the nostrils, the gums, and the fundament, occasionally also from the mouth.[1] Such haemorrhages are of a passive kind, and not violent as are those from the windpipe.

The great vessel and the aorta, which above lie somewhat apart, lower down exchange positions, and by so doing give compactness to the body. For when they reach the point[2] where the legs diverge, they each split into two, and the great vessel passes from the front to the rear, and the aorta from the rear to the front. By this they contribute to the unity of the whole fabric. For as in plaited work the parts hold more firmly together because of the interweaving, so also by the interchange of position between the blood-vessels are the anterior and posterior parts of the body more closely knit together. A similar exchange of position occurs also in the upper part of the body, between the vessels that have issued from the heart.[3] The details however of the mutual relations of the different vessels must be looked for in the treatises on Anatomy and the Researches concerning Animals.[4]

So much, then, as concerns the heart and the blood-vessels. We must now pass on to the other viscera and apply the same method of inquiry to them.

6 The lung,[5] then, is an organ found in all the animals of

[1] The mention of gums and mouth points to the existence of scurvy in those days.

[2] The common iliac arteries, formed by the division of the descending aorta, do in fact, as A. says, come forwards and lie in front of the common iliac veins ; whereas as a general rule the veins lie in front of the arteries.

[3] The pulmonary artery, regarded by A. as a part of the μεγάλη φλέψ, at its origin is in front of the aorta, but when it reaches the arch sends its right and larger division behind the ascending aorta. It is probably to this that A. alludes.

[4] Cf. *H. A.* i. 17 ; iii. 2–4.

[5] It will be noticed that A. always speaks of *the lung* of an animal, and not as we do of *the lungs*. He considers the two to be merely subdivisions of a single organ, because they have one common outlet, viz. the trachea. When the right and left bronchi which lead from this to either lung are of more than ordinary length, as in birds, he admits that the lung has the outward appearance of being a double organ, but still considers it really to be a single one for the above

a certain class, because they live on land. For there must of necessity be some means or other of tempering the heat of the body; and in sanguineous animals, as they are of an especially hot nature, the cooling agency must be external,
669a whereas in the bloodless kinds the innate spirit is sufficient of itself for the purpose. The external cooling agent must be either air or water. In fishes the agent is water. Fishes therefore never have a lung, but have gills in its place, as was stated in the treatise on Respiration.[1] But animals that breathe are cooled by air. These therefore are all provided with a lung.

All land animals breathe, and even some water animals, such as the whale, the dolphin, and all the spouting Cetacea. For many animals lie half-way between terrestrial and aquatic; some that are terrestrial and that inspire air being nevertheless of such a bodily constitution that they abide for the most time in the water; and some that are aquatic partaking so largely of the land character, that respiration constitutes for them the main condition of life.

The organ of respiration is the lung. This derives its motion from the heart; but it is its own large size and spongy texture that affords amplitude of space for the entrance of the breath. For when the lung rises up the breath streams in, and is again expelled when the lung collapses.[2] It has been said [3] that the lung exists as a provision

reason; though 'any one might think that there were two because the ducts from the two divisions unite at a considerable distance from them' *H. A.* ii. 17. 507^{a} 19; *P. A.* iii. 7. 669^{b} 24.

[1] *De Resp.* 10. 475^{b} 15 sq.

[2] The mechanism of respiration is described elsewhere (*De Resp.* 21). The lung is compared, aptly enough, to a pair of forge bellows. When the lung is expanded, air rushes in; when it is contracted, the air is again expelled. The expansion is brought about by the heat derived from the heart; heat always causing expansion in the parts to which it extends. The lung then, heated by the heart, expands; and with it the cavity of the thorax. Cold air rushes in to fill the void, and the heat is reduced. This causes the lung and thorax to collapse, and the air is expelled.

[3] Plato (*Tim.* 70 C) regarded the lung as a soft yielding buffer, intended to receive the impact of the heart, when throbbing violently in fits of emotion. To this A. objects that animals that are not liable to such fits of emotion nevertheless have lungs; and, moreover, that the lung is not placed on the side of the heart where the impact occurs; that is, not on the sternal aspect.

to meet the jumping of the heart. But this is out of the question. For man is practically the only animal whose heart presents this phenomenon of jumping, inasmuch as he alone is influenced by hope and anticipation of the future. Moreover, in most animals the lung is separated from the heart[1] by a considerable interval and lies above it, so that it can contribute nothing to mitigate any jumping.

The lung differs much in different animals. For in some it is of large size and contains blood; while in others it is smaller and of spongy texture. In the vivipara it is large and rich in blood, because of their natural heat; while in the ovipara it is small and dry but capable of expanding to a vast extent when inflated. Among terrestrial animals, the oviparous quadrupeds, such as lizards, tortoises, and the like, have this kind of lung; and, among inhabitants of the air, the animals known as birds.[2] For in all these the lung is spongy, and like foam. For it is membranous and collapses from a large bulk to a small one, as does foam when it runs together. In this too lies the explanation of the fact that these animals are little liable to thirst and drink but sparingly, and that they are able to remain for a considerable time under water. For, inasmuch as they 669b
have but little heat, the very motion of the lung, airlike and void, suffices by itself to cool them for a considerable period.[3]

These animals, speaking generally, are also distinguished from others by their smaller bulk. For heat promotes

[1] The natural nominative to ἀπέχει, as the text stands, is ὁ πλεύμων, and this, as also the sense, requires that for τοῦ πλεύμονος should be read τῆς καρδίας; for in no sense can the heart be said to be *above* the lung, nor would such a position invalidate Plato's notion, whereas 'in most animals', that is in quadrupeds, the lung is placed above the heart, and away from the side where the heart's impact occurs.

[2] The lungs of birds, though smaller in proportion to the body than those of mammals, are highly vascular.

[3] A. seems to have had some strange notion that a fan cools a body not merely by bringing a continuous current of cold air into contact with it, but directly by its own motion, that is independently of the air. 'Every hot body,' he says, 'is cooled by the motions of bodies external to itself' (iii. 4. 667a 28). So he supposes here that when an animal is under water, its lung will continue in motion, and that, though no air is admitted, yet the motion will itself produce a certain amount of cooling in the neighbouring parts. See also *De Resp.* 9. 475a 14.

growth, and abundance of blood is a sure indication of heat. Heat, again, tends to make the body erect; and thus it is that man is the most erect of animals, and the vivipara more erect than other quadrupeds. For no viviparous animal, be it apodous[1] or be it possessed of feet, is so given to creep into holes as are the ovipara.

The lung, then, exists for respiration; and this is its universal office; but in one order of animals it is bloodless and has the structure described above, to suit the special requirements. There is, however, no one term to denote all animals that have a lung; no designation, that is, like the term Bird, applicable to the whole of a certain class. Yet the possession of a lung is a part of their essence, just as much as the presence of certain characters constitutes the essence of a bird.

Of the viscera some appear to be single, as the heart 7
and lung; others to be double, as the kidneys; while of a third kind it is doubtful in which class they should be reckoned. For the liver and the spleen would seem to lie half-way between the single and the double organs. For they may be regarded either as constituting each a single organ, or as a pair of organs resembling each other in character.[2]

In reality, however, all the organs are double. The reason for this is that the body itself is double, consisting of two halves, which are however combined together under

[1] Meaning the viper, which is apparently said to be less of a troglodyte than its congeners, because other snakes conceal themselves underground during their period of torpor, while the viper remains on the surface, hiding under stones. (*H. A.* viii. 15. 599b 1.)

[2] It seems to have been the universal opinion of the ancients that the spleen was the left homologue of the liver. In modern times the more general view is that of Müller, that there is no such relation between them, each being an azygos organ. The ancient opinion is not, however, without its modern advocates. Dr. Doellinger, for instance (*Grundriss der Naturlehre des menschl. Organ.* 1805), supported it; and more recently Dr. Sylvester (*The Discov. of the Nature of the Spleen*, 1870) has argued with much ingenuity that 'the spleen is not a blood-gland in the mesial line of the body, having no homologous relationship with the liver,' but that 'it is the left lateral homologue of a portion of the liver, the latter being a combination of a sanguiferous gland and a biliary apparatus,' and the spleen the homologue of the former portion of it.

one supreme centre. For there is an upper and a lower half, a front and a rear, a right side and a left.

This explains why it is that even the brain and the several organs of sense tend in all animals to consist of two parts; and the same explanation applies to the heart with its cavities. The lung again in Ovipara is divided to such an extent that these animals look as though they had actually two lungs. As to the kidneys, no one can overlook their double character. But when we come to the liver and the spleen, any one might fairly be in doubt. The reason of this is, that, in animals that necessarily have a spleen,[1] this organ is such that it might be taken for a kind of bastard liver; while in those [2] in which a spleen is not an actual necessity but is merely present, as it were, by way of token, in an extremely minute form, the liver plainly consists of two parts; of which the larger tends to lie on the right side and the smaller on the left.[3] Not but what there are some even of the Ovipara in which this condition is comparatively indistinctly marked; while, on the other hand, there are some Vivipara in which the liver is manifestly divided into two parts.[4] Examples of such

[1] That is to say in the viviparous quadrupeds.

[2] Namely the Ovipara.

[3] There is some foundation for the statement that the size of the spleen and the distinctness with which the liver is divided into lobes are inversely related to each other. Thus it is in Mammalia that the spleen is largest in proportion to the body, and in them also that the liver is least distinctly lobulated. Among Mammalia it is the rodents that have the smallest spleen, and in these also it is that the liver reaches its maximum of sub-division. On the other hand, the spleen is large in ruminants and their liver at the same time presents scarcely any marks of lobulation. In the Ovipara the spleen is much smaller than in Mammalia, and the liver, as a general though not universal rule, is much more decidedly cleft into distinct lobes. In all birds, in all batrachians, and in all reptiles, excepting Ophidia, the liver is distinctly divided into two lobes. In the remaining class, fishes, the spleen varies much in size; sometimes is apparently altogether absent, sometimes excessively small, sometimes almost as large in proportion to the body as that of a mammal, and the liver is sometimes multilobed, sometimes bilobed, sometimes unilobed. In this class, however, I cannot ascertain that there is any such relation as that mentioned in the text between the two conditions.

[4] The exceptional ovipara are the Ophidia and many osseous fishes, where the liver is unilobed. The exceptional vivipara are the rodents, of which A. specially mentions the hare. Omit κἀκεῖ and ὥσπερ ἔν τισι (EY).

division are furnished by the hares of certain regions, which have the appearance of having two livers, and by the cartilaginous and some other fishes.[1]

It is the position of the liver on the right side of the
670a body that is the main cause for the formation of the spleen; the existence of which thus becomes to a certain extent a matter of necessity in all animals, though not of very stringent necessity.

The reason, then, why the viscera are bilateral is, as we have said, that there are two sides to the body, a right and a left. For each of these sides aims at similarity with the other, and so likewise do their several viscera; and[2] as the sides, though dual, are knit together into unity, so also do the viscera tend to be bilateral and yet one by unity of constitution.

Those viscera which lie below the diaphragm exist one and all on account of the blood-vessels;[3] serving as a bond, by which these vessels, while floating freely, are yet held in connexion with the body. For the vessels give off branches which run to the body through the outstretched structures,[4] like so many anchor-lines thrown out from a ship. The great vessel sends such branches to the liver and the spleen; and these viscera—the liver and spleen on either side with the kidneys behind—attach the great vessel to the body with the firmness of nails.[5] The aorta sends similar branches to each kidney, but none to the liver or spleen.[6]

These viscera, then, contribute in this manner to the compactness of the animal body. The liver and spleen assist, moreover, in the concoction of the food; for both are

[1] In cartilaginous fishes the liver consists of two distinct lobes, whereas in osseous fishes it is often unilobed.

[2] Reading *καὶ καθάπερ* (PZ).

[3] Assisting them in the mechanical way immediately mentioned, and also by providing an outlet for their surplus blood. Cf. iii. 10. 673b 1.

[4] The mesentery is meant.

[5] The introduction of nails into the metaphor is so out of place, that the temptation is strong to substitute *εὐναί*—mooring-stones—for *ἧλοι*. The metaphor would then run on all fours; the ship being the main blood-vessel; the anchor-lines its outstretching branches; the mooring-stones the liver, spleen, kidneys.

[6] The hepatic and splenic arteries seem to have escaped A.'s notice; probably because they are not given off directly from the aorta.

of a hot character, owing to the blood which they contain. The kidneys, on the other hand, take part in the separation of the excretion which flows into the bladder.

The heart then and the liver are essential constituents of every animal; the liver that it may effect concoction, the heart that it may lodge the central source of heat. For some part or other there must be which, like a hearth, shall hold the kindling fire; and this part must be well protected, seeing that it is, as it were, the citadel of the body.

All sanguineous animals, then, need these two parts; and this explains why these two viscera, and these two alone, are invariably found in them all. In such of them, however, as breathe, there is also as invariably a third, namely the lung. The spleen, on the other hand, is not invariably present; and, in those animals that have it, is only present of necessity in the same sense as the excretions of the belly and of the bladder are necessary, in the sense, that is, of being an inevitable concomitant. Therefore it is that in some animals the spleen is but scantily developed as regards size. This, for instance, is the case in such feathered animals as have a hot stomach. Such are the pigeon, the hawk, and the kite.[1] It is the case also in oviparous quad- **670b**
rupeds, where the spleen is excessively minute, and in many of the scaly fishes. These same animals are also without a bladder, because the loose texture of their flesh allows the residual fluid to pass through and to be applied to the formation of feathers and scales. For the spleen attracts the residual humours[2] from the stomach, and owing to its bloodlike character is enabled to assist in their concoction. Should, however, this residual fluid be too abundant, or the heat of the spleen be too scanty, the body becomes sickly from over-repletion[3] with nutriment. Often, too, when the

[1] The spleen is small in all birds, but whether specially so in these, or in the owl, which he adds elsewhere (*H. A.* ii. 15. 506a 13) to the list, I cannot say.

[2] The notion that the spleen serves to attract superfluous humours is taken from Hippocrates, who thus expresses himself, 'I say that when a man drinks a more than ordinary amount of fluid, both the body and the spleen attract to themselves the water from the stomach' (*De Morbis*, iv. 9 and *De Morb. Mul.* i. 15).

[3] Reading πλήθει for πλήρη.

spleen is affected by disease, the belly becomes hard [1] owing to the reflux into it of the fluid ; just as happens to those who form too much urine, for they also are liable to a similar diversion of the fluids into the belly. But in those animals that have but little superfluous fluid to excrete, such as birds and fishes, the spleen is never large, and in some exists no more than by way of token. So also in the oviparous quadrupeds it is small, compact, and like a kidney. For their lung is spongy, and they drink but little, and such superfluous fluid as they have is applied to the growth of the body and the formation of scaly plates, just as in birds it is applied to the formation of feathers.

On the other hand, in such animals as have a bladder, and whose lung contains blood, the spleen is watery, both for the reason already mentioned, and also because the left side of the body is more watery and colder than the right. For each of two contraries has been so placed as to go together with that which is akin to it in another pair of contraries. Thus right and left, hot and cold, are pairs of contraries ; and right is conjoined with hot, after the manner described, and left with cold.

The kidneys when they are present exist not of actual necessity, but as matters of greater finish and perfection. For by their special character they are suited to serve in the excretion of the fluid which collects in the bladder. In animals therefore where this fluid is very abundantly formed, their presence enables the bladder to perform its proper office with greater perfection.[2]

Since then both kidneys and bladder exist in animals for one and the same function, we must next treat of the bladder, though in so doing we disregard the due order of succession in which the parts should be enumerated. For not a word has yet been said of the midriff, which is one of the parts that environ the viscera and therefore has to be considered with them.

[1] Also from Hippocrates (Kühn's Ed. i. 533).

[2] A. thought that the bladder was the essential agent in forming the urine, the kidneys being comparatively unimportant adjuncts, though he also admits that when the fluid leaves these organs, it already has in a measure the characters of the final excretion. Cf. iii. 9. 671^{b} 24.

8 It is not every animal that has a bladder; those only being apparently intended by nature to have one, whose lung contains blood. To such it was but reasonable that 671a she should give this part. For the superabundance in their lung of its natural constituents causes them to be the thirstiest of animals, and makes them require a more than ordinary quantity not merely of solid but also of liquid nutriment. This increased consumption necessarily entails the production of an increased amount of residue; which thus becomes too abundant to be concocted by the stomach and excreted with its own residual matter. The residual fluid must therefore of necessity have a receptacle of its own; and thus it comes to pass that all animals whose lung contains blood are provided with a bladder. Those animals, on the other hand, that are without a lung of this character, and that either drink but sparingly owing to their lung being of a spongy texture, or never imbibe fluid at all for drinking's sake but only as nutriment, insects for instance and fishes, and that are moreover clad with feathers or scales or scaly plates[1]—all these animals, owing to the small amount of fluid which they imbibe, and owing also to such residue as there may be being converted into feathers and the like, are invariably without a bladder.[2] The Tortoises, which are comprised among animals with scaly plates, form the only exception; and this is merely due to the imperfect development of their natural conformation; the explanation of the matter being that in the sea-tortoises the lung is flesh-like and contains blood, resembling the lung of the ox, and that in the land-tortoises it is of disproportionately

[1] A. distinguishes the scales of fishes from those of reptiles by giving them distinct names, but nowhere discusses their differences excepting that he says (iv. 2. 691a 16) 'these plates (φολίδες) are equivalent to scales (λεπίδες) but of a harder character'. But see iv. 13. 697a 5 note.

[2] All viviparous quadrupeds, i. e. Mammalia, have (Monotremata excepted) a urinary bladder. Birds have none. In many fishes the ureters form a small dilatation or bladder. Among reptiles, Ophidia and many Saurians have no bladder; but there is one in some Saurians and in all Chelonia, and in these latter it is of great size.

A. is mistaken in supposing that tortoises drink but little. Darwin describes them as wearing broad and well-beaten paths to the springs in Chatham Island (*Voyage of Beagle*, p. 383).

large size.[1] Moreover, inasmuch as the covering which invests them is dense and shell-like, so that the moisture cannot exhale through the porous flesh, as it does in birds and in snakes and other animals with scaly plates, such an amount of secretion is formed that some special part is required to receive and hold it. This then is the reason why these animals, alone of their kind, have a bladder, the sea-tortoise a large one, the land-tortoises an extremely small one.[2]

What has been said of the bladder is equally true of the 9
kidneys. For these also are wanting in all animals that are clad with feathers or with scales or with scale-like plates; the sea and land tortoises[3] forming the only exception. In some of the birds, however, there are flattened kidney-like bodies, as though the flesh allotted to the formation of the kidneys, unable to find one single place of sufficient size, had been scattered over several.[4]

[1] The lungs of Chelonia are of much greater size than those of most Saurians and Amphibia, and 's'étendent le long du dos jusqu'au bassin au-dessus de tous les viscères' (Cuvier, *Leçons*, iv. 347). They are, moreover, not only thus larger, but contain 'in correlation with the non-transpirable integument a much greater development of internal parenchyma' (Rolleston, *Forms of An. Life*, lx). This comparative abundance of parenchyma is more marked in marine than in other tortoises (Cuvier, *Leçons*, iv. 324 and 332).

[2] Perrault found on repeated dissections that precisely the contrary was the case, and consequently inferred 'qu'il y a faute au texte par la transposition des mots *terrestre* et *marine*' (*Mém. pour servir à l'hist. nat. des Animaux*, 2e *partie*, *p.* 403).

[3] A similar statement, that no Ovipara save the tortoises have kidneys, is made elsewhere (*H.A.* ii. 16); where also it is said that the kidney of the tortoise consists, like that of the ox, of numerous smaller parts. The chelonian kidney is, in fact, extremely subdivided on the outer surface; so that there can be no doubt that A. had examined it. But it is difficult to understand how the kidneys of other Ovipara escaped his notice. It is true they are so differently shaped from those of a mammal, or even of a tortoise, that they might appear to a careless observer to be totally different organs. But the probable explanation is that A. argued *a priori* that it was impossible for there to be a kidney if there was no bladder. For the essential organ in the formation of urine was, as he thought, not the kidney, but the bladder; and the kidneys were but adjuncts to this (iii. 7.670b 28 note). A kidney, then, in an animal without a bladder was to A. just as absurd a supposition as would be to us a urinary bladder when there was no kidney. That A. was misled by this preconception is shown by the fact that he did see the kidneys in birds, and did recognize their kidney-like aspect; but yet refused to consider them as true kidneys.

[4] In birds the kidneys, almost always trilobed, are flattened against

The Emys[1] has neither bladder nor kidneys. For the softness of its shell allows of the ready transpiration of fluid; and for this reason neither of the organs mentioned exists in this animal. All other animals, however, whose lung contains blood are, as before said, provided with kidneys. For nature uses these organs for two separate 671b purposes, namely for the excretion of the residual fluid, and to subserve the blood-vessels,[2] a channel leading to them from the great vessel.

In the centre of the kidney is a cavity of variable size. This is the case in all animals, excepting the seal.[3] The kidneys of this animal are more solid than those of any other, and in form resemble the kidneys of the ox. The human kidneys are of similar shape; being as it were made up of numerous small kidneys,[4] and not presenting one unbroken surface like the kidneys of sheep and other quadrupeds.[5] For this reason, should the kidneys of a man be once attacked by disease, the malady is not easily expelled. For it is as though many kidneys were diseased and not merely one; which naturally enhances the difficulties of a cure.

The duct which runs to the kidney from the great vessel does not terminate in the central cavity, but is expended on the substance of the organ, so that there is no blood in the cavity, nor is any coagulum found there after death. A pair of stout ducts, void of blood, run, one from the cavity of each kidney, to the bladder; and other ducts, strong and

the back, and, fitting into the deep interspaces between the bones, retain the impressions of these successive cavities or depressions.

[1] The Emys was some freshwater tortoise (*H. A.* v. 33. 558^{a} 8); but what species is uncertain, as there are several in Greece. None is without a bladder, but this is equally true of all known Chelonia. Neither has any animal now known as Emys a soft shell.

[2] Cf. iii. 7. 670^{a} 8 note.

[3] The cavity in the seal's kidney is very small. It is pictured in section by Buffon (*Hist. Nat.* xiii. pl. 48). The kidney consists of numerous distinct lobes, and in this respect resembles that of an ox.

[4] This is not true of adult man, excepting as an occasional anomaly. But it is true of the foetus. This is one of the statements which lead me to think that A. may have dissected the human foetus.

[5] Not all quadrupeds other than the ox have non-lobulated kidneys, though such is the general rule. The elephant, bear, otter, all have lobulated kidneys.

continuous, lead into the kidneys from the aorta.[1] The purpose of this arrangement is to allow the superfluous fluid to pass from the blood-vessel into the kidney, and the resulting renal excretion to collect, by the percolation of the fluid through the solid substance of the organ, in its centre, where as a general rule there is a cavity. (This by the way explains why the kidney is the most ill-savoured of all the viscera.) From the central cavity the fluid is discharged into the bladder by the ducts that have been mentioned, having already assumed in great degree the character of excremental residue.[2] The bladder is as it were moored to the kidneys; for, as already has been stated, it is attached to them by strong ducts. These then are the purposes for which the kidneys exist, and such the functions of these organs.

In all animals that have kidneys, that on the right is placed higher than that on the left.[3] For, inasmuch as motion commences from the right,[4] and the organs on this side are in consequence stronger than those on the left, they must all push upwards in advance of their opposite fellows; as may be seen in the fact that men even raise the right eyebrow more than the left, and that the former is more arched than the latter. The right kidney being thus drawn upwards is in all animals brought into contact with the liver; for the liver lies on the right side.

672^{a} Of all the viscera the kidneys are those that have the most fat. This is in the first place the result of necessity, because the kidneys are the parts through which the residual matters percolate. For the blood which is left behind after this excretion, being of pure quality, is of easy concoction, and the final result of thorough blood-concoction is lard and suet. For just as a certain amount of fire is left in the ashes of solid substances after combustion, so also does a remnant of the heat that has been developed remain in

[1] The bloodless ducts are the ureters. The ducts from the aorta and great vessel are the renal arteries and veins respectively.

[2] Cf. iii. 7. 670^{b} 28 note.

[3] This is the general but not universal rule. One of the exceptions is man, where the right kidney is usually slightly lower than the left.

[4] Cf. *De Caelo*, ii. 2. 284^{b} 28 and *De An. Inc.* 4. 705^{b} 29; 6. 706^{b} 17.

fluids after concoction; and this is the reason why oily matter is light, and floats on the surface of other fluids. The fat is not formed in the kidneys themselves, the density of their substance forbidding this, but is deposited about their external surface. It consists of lard or of suet, according as the animal's fat is of the former or latter character. The difference between these two kinds of fat has already been set forth in other passages.[1] The formation, then, of fat in the kidneys is the result of necessity; being, as explained, a consequence of the necessary conditions which accompany the possession of such organs. But at the same time the fat has a final cause, namely to ensure the safety of the kidneys, and to maintain their natural heat. For placed, as these organs are, close to the surface, they require a greater supply of heat than other parts. For while the back is thickly covered with flesh, so as to form a shield for the heart and neighbouring viscera, the loins, in accordance with a rule that applies to all bendings, are destitute of flesh; and fat is therefore formed as a substitute for it, so that the kidneys may not be without protection. The kidneys, moreover, by being fat are the better enabled to secrete and concoct their fluid; for fat is hot, and it is heat that effects concoction.

Such, then, are the reasons why the kidneys are fat. But in all animals the right kidney is less fat than its fellow.[2] The reason for this is, that the parts on the right side are naturally more solid and more suited for motion than those on the left. But motion is antagonistic to fat, for it tends to melt it.

Animals then, as a general rule, derive advantage from their kidneys being fat; and the fat is often very abundant and extends over the whole of these organs. But, should the like occur in the sheep, death ensues. Be its kidneys, however, as fat as they may, they are never so fat but that some part, if not in both at any rate in the right one, is left free. The reason why sheep are the only animals that suffer in this manner, or suffer more than others, is that in

[1] Cf. ii. 5, *H.A.* iii. 17.
[2] Aubert and Wimmer say this is true of rabbits.

animals whose fat is composed of lard[1] this is of fluid consistency, so that there is not the same chance in their case of wind getting shut in and causing mischief. But it is to such an enclosure of wind that rot[2] is due. And thus even in men, though it is beneficial to them to have fat kidneys, yet should these organs become over-fat and diseased, deadly pains ensue. As to those animals whose fat consists of
672b suet, in none is the suet so dense as in the sheep, neither is it nearly so abundant; for of all animals there is none in which the kidneys become so soon gorged with fat as in the sheep.[3] Rot, then, is produced by the moisture and the wind getting shut up in the kidneys, and is a malady that carries off sheep with great rapidity. For the disease forthwith reaches the heart, passing thither by the aorta and the great vessel, the ducts which connect these with the kidneys being of unbroken continuity.

We have now dealt with the heart and the lung, as also with the liver, spleen, and kidneys. The latter are sepa- **10**
rated from the former by the midriff or, as some call it, the *Phrenes.* This divides off the heart and lung, and, as already said, is called *Phrenes* in sanguineous animals, all[4] of which have a midriff, just as they all have a heart and a liver. For they require a midriff to divide the region of the heart from the region of the stomach, so that the centre wherein abides the sensory soul may be undisturbed, and not be overwhelmed, directly food is taken, by its up-steaming vapour and by the abundance of heat then superinduced. For it was to guard against this that nature made a division,

[1] Cf. ii. 5. 651a 35.

[2] A. is plainly speaking of some disease that is compatible with accumulation of fat, and that also is, at any rate sometimes, rapidly fatal. Such seems to be the case with rot. 'In this disease there is no loss of condition, but quite the contrary. For the sheep in the early stages of rot has a great propensity to fatten' (Youatt, *Book of Farm,* ii. 386). Again, the rot is sometimes 'rapid in its course, and this season a large number of sheep have been killed very quickly by it' (Gamgee, *Pr. Counc. Rep.* v. 240).

[3] The ox and the sheep, says John Hunter, have more fat about the kidneys, the loins, and within the abdomen, than most other animals (*Museum Cat.* iii. 312).

[4] Mammals alone have a perfect diaphragm, but in most vertebrates there is something analogous to it. The description, however, given further on, applies only to the perfect diaphragm, viz. that of mammals.

constructing the midriff as a kind of partition-wall and fence, and so separated the nobler from the less noble parts, in all cases where a separation of upper from lower is possible. For the upper part is the more honourable, and is that for the sake of which the rest exists; while the lower part exists for the sake of the upper and constitutes the necessary element in the body, inasmuch as it is the recipient of the food.

That portion of the midriff which is near the ribs is fleshier and stronger than the rest, but the central part has more of a membranous character; for this structure conduces best to its strength and its extensibility. Now that the midriff, which is a kind of outgrowth from the sides of the thorax, acts as a screen to prevent heat mounting up from below, is shown by what happens, should it, owing to its proximity to the stomach, attract thence the hot and residual fluid. For when this occurs there ensues forthwith a marked disturbance of intellect and of sensation. It is indeed because of this that the midriff is called [1] *Phrenes*, as though it had some share in the process of thinking (*Phronein*). In reality, however, it has no part whatsoever itself in the matter, but, lying in close proximity to organs that have, it brings about the manifest changes of intelligence in question by acting upon them. This too explains why its central part is thin. For though this is in some measure the result of necessity, inasmuch as those portions of the fleshy whole which lie nearest to the ribs must necessarily be fleshier than the rest,[2] yet besides this there is a final cause, namely to give it as small a proportion of humour as possible; for, had it been made of flesh throughout, it 673a
would have been more likely to attract and hold a large amount of this. That heating of it affects sensation rapidly and in a notable manner is shown by the phenomena of laughing. For when men are tickled they are quickly set a-laughing, because the motion quickly reaches this part,

[1] A notion still commemorated in the anatomical terms 'phrenic nerves' and 'phrenic centre'.

[2] The central part of the midriff, which is tendinous, is the 'cordiform tendon' of modern anatomists.

and heating[1] it though but slightly nevertheless manifestly so disturbs the mental action as to occasion movements that are independent of the will. That man alone is affected by tickling is due firstly to the delicacy of his skin, and secondly to his being the only animal that laughs. For to be tickled is to be set in laughter, the laughter being produced by such a motion as mentioned of the region of the armpit.

It is said also that when men in battle are wounded anywhere near the midriff, they are seen to laugh,[2] owing to the heat produced by the wound. This may possibly be the case. At any rate it is a statement made by much more credible persons than those who tell the story of the human head, how it speaks after it is cut off. For so some assert, and even call in Homer to support them, representing him as alluding to this when he wrote,[3] 'His head still speaking rolled into the dust,' instead of 'The head of the speaker'. So fully was the possibility of such an occurrence accepted in Caria, that one of that country was actually brought to trial under the following circumstances. The priest of Zeus Hoplosmios[4] had been murdered; but as yet it had not been ascertained who was the assassin; when certain persons asserted that they had heard the murdered man's head, which had been severed from the body, repeat several times the words, 'Cercidas slew man on man.' Search was thereupon made and a man of those parts who bore the name of Cercidas hunted out and put upon his trial. But it is impossible that any one should utter a word when the windpipe is severed and no motion any longer derived from the lung. Moreover, among the Barbarians, where heads are chopped off with great rapidity, nothing of the kind has ever yet occurred. Why, again, does not the like occur in

[1] Reading *θερμαίνουσαν* (PUY) for *θερμαίνουσι*, with a comma before it; but the text of this passage is too corrupt for more than conjectural interpretation.

[2] When the diaphragm is suddenly ruptured, instant death usually follows, and the face is said invariably to assume the peculiar expression or grin, called *Risus Sardonicus*. Cf. *Dict. d. Sci. Médic.* ix. 214.

[3] *Iliad* x. 457; *Odyssey* xxii. 329. In both places the reading is *φθεγγομένου* not *φθεγγομένη*.

[4] Probably meaning 'armed' Zeus. So too there was a temple of Here Hoplosmia in the Peloponnesus. (Liddell and Scott.)

the case of other animals than man? For that none of them should laugh, when their midriff is wounded, is but what one would expect; for no animal but man ever laughs. So, too, there is nothing irrational in supposing that the trunk may run forwards to a certain distance after the head has been cut off; seeing that bloodless animals at any rate can live, and that for a considerable time, after decapitation, as has been set forth and explained in other passages.[1]

The purposes, then, for which the viscera severally exist have now been stated. It is of necessity upon the inner terminations of the vessels that they are developed; for humour, and that of a bloody character, cannot but exude at these points, and it is of this, solidified and coagulated, 673b
that the substance of the viscera is formed.[2] Thus they are of a bloody character, and in substance resemble each other while they differ from other parts.

11 The viscera are enclosed each in a membrane. For they require some covering to protect them from injury, and require, moreover, that this covering shall be light. To such requirements membrane is well adapted; for it is close in texture so as to form a good protection, destitute of flesh so as neither to attract humour nor retain it, and thin so as to be light and not add to the weight of the body. Of the membranes those are the stoutest and strongest which invest the heart and the brain;[3] as is but consistent with reason. For these are the parts which require most protection, seeing that they are the main governing powers of life, and that it is to governing powers that guard is due.

12 Some animals have all the viscera that have been enumerated; others have only some of them. In what kind of animals this latter is the case, and what is the explanation, has already been stated.[4] Moreover, the self-same viscera present differences in different possessors. For the heart is

[1] Cf. iii. 5. 677b 27 note; *De An.* i. 5. 411b 19; ii. 2. 413b 20; *De Long. Vit. Iuv. et Sen.* 6. 467a 19; *De Vita*, 2. 468a 25, b 2; *De Resp.* 3. 471b 20; *H. A.* iv. 7. 531b 30 – 532a 5; *De Inc. An.* 7. 707a 27.
[2] Cf. ii. 15. 658b 24 note.
[3] The pericardium and dura mater.
[4] Cf. iii. 4. 665a 29.

not precisely alike in all animals that have one ; nor, in fact, is any viscus whatsoever. Thus the liver is in some animals split into several parts, while in others it is comparatively undivided.[1] Such differences in its form present themselves even among those sanguineous animals that are viviparous, but are more marked in fishes and in the oviparous quadrupeds, and this whether we compare them with each other or with the Vivipara. As for birds, their liver very nearly resembles that of the Vivipara ; for in them, as in these, it is of a pure and blood-like colour. The reason of this is that the body in both these classes of animals admits of the freest exhalation, so that the amount of foul residual matter within is but small. Hence it is that some of the Vivipara are without any gall-bladder[2] at all. For the liver takes a large share in maintaining the purity of composition and the healthiness of the body. For these are conditions that depend finally and in the main upon the blood, and there is more blood in the liver than in any of the other viscera, the heart only excepted. On the other hand, the liver of oviparous quadrupeds and fishes inclines, as a rule, to a yellow hue,[3] and there are even some of them in which it is entirely of this bad colour,[4] in accordance with the bad composition of their bodies generally. Such, for instance, is the case in the toad, the tortoise, and other similar animals.

The spleen, again, varies in different animals. For in those that have horns and cloven hoofs, such as the goat, the sheep, and the like, it is of a rounded form ;[5] excepting when increased size has caused some part of it to extend its
674a growth longitudinally, as has happened in the case of the

[1] Cf. iii. 7. 669b 32, 35 notes. [2] Cf. iv. 2. 676b 26.

[3] The liver of mammals and birds is as a rule of a brown-red colour. In reptiles it inclines to a yellow hue ; and in fishes this yellow tint is often still more decided. Cf. Cuvier, *Leçons*, iv. 14–16.

[4] 'Bad' because the degree of yellowness is to A. a measure of the impurity which the liver has to separate from the blood. Perhaps also with some reference to the views of the soothsayers, who seem to have considered a pale liver to be an unfavourable omen, the lucky tint being the normal mottled red, the ποικίλη εὐμορφία of Aeschylus ; in which case 'bad' would correspond to the *turpia exta* of Livy (xxvii. 26).

[5] Or perhaps 'of a broad oval form'; στρογγύλος being the term applied to a merchant vessel as distinguished from a ship of war.

ox. On the other hand, it is elongated in all polydactylous animals.[1] Such, for instance, is the case in the pig,[2] in man, and in the dog. While in animals with solid hoofs it is of a form intermediate to these two, being broad in one part, narrow in another. Such, for example, is its shape in the horse, the mule, and the ass.

13 The viscera differ from the flesh not only in the turgid aspect of their substance, but also in position; for they lie within the body, whereas the flesh is placed on the outside. The explanation of this is that these parts partake of the character of blood-vessels, and that while the former exist for the sake of the vessels, the latter cannot exist without them.[3]

14 Below the midriff lies the stomach, placed at the end of the oesophagus when there is one, and in immediate contiguity with the mouth when the oesophagus is wanting. Continuous with this stomach is what is called the gut. These parts are present in all animals, for reasons that are self-evident. For it is a matter of necessity that an animal

[1] The spleen 'is broader at one end in the cow, reindeer, and giraffe than in other ruminants' (Owen, *Verteb.* iii. 561). In the hog it is elongated; so also in Carnivora generally. In the Ungulata it is of proportionately smaller dimensions than in the Carnivora, and in the horse is 'elongated, flattened, broadest at the upper end'. A.'s account so far therefore fairly tallies with the facts. But as regards man his statement is erroneous. For though the human spleen is very variable in shape as in size, yet it cannot be said to be elongated in comparison with that of other mammalia.

[2] A. seems to have been at a loss to classify the pig. Here he reckons it with the many-toed animals in opposition to the animals with solid or cloven hoofs. In the next chapter he separates it from the many-toed, and puts it into a separate division, consisting of 'those that have a cloven hoof, but yet have front teeth in both jaws'; of course in contradistinction to the ruminants. In another place (*H. A.* ii. 1. 499^{b} 12) he says the pig lies half-way between the cloven-hoofed and the solidungulates; and, in corroboration of this, states that there are sometimes pigs with a solid hoof; an anomaly of which instances do in fact occur not very rarely.

The foot of the pig has in reality four toes; but of these the two middle ones are much longer and stouter than the others, and form a cloven hoof which is used by the animal in walking. The two lateral toes are also furnished with hoofs, but are placed at some distance above the ground, so as not to touch it.

[3] It is the viscera that exist 'for the sake of the vessels' (iii. 7. 670^{a} 8), the flesh that 'cannot exist without them' (iii. 5. 668^{a} 32).

shall receive the incoming food ; and necessary also that it shall discharge the same when its goodness is exhausted. This residual matter, again, must not occupy the same place as the yet unconcocted nutriment. For as the ingress of food and the discharge of the residue occur at distinct periods, so also must they necessarily occur in distinct places. Thus there must be one receptacle for the ingoing food and another for the useless residue, and between these, therefore, a part in which the change from one condition to the other may be effected. These, however, are matters which will be more suitably set forth when we come to deal with Generation and Nutrition.[1] What we have at present to consider are the variations presented by the stomach and its subsidiary parts. For neither in size nor in shape are these parts uniformly alike in all animals. Thus the stomach is single in all such sanguineous and viviparous animals as have teeth in front of both jaws. It is single therefore in all the polydactylous kinds, such as man, dog, lion, and the rest ; in all the solid-hoofed animals also, such as horse, mule, ass ; and in all those which, like the pig, though their hoof is cloven, yet have front teeth in both jaws.[2] When, however, an animal is of large size, and feeds on substances of so thorny and ligneous a character as to be difficult of concoction, it may in consequence have several stomachs, as for instance is the case with the camel. A similar multiplicity of stomachs exists also in the horned animals ; the reason being that horn-bearing animals have no front teeth in the upper jaw. The camel also, though it has no horns, is yet without upper front teeth.[3] The explanation of this is that it is more essential for the camel to have a multiple stomach than to have these teeth. Its stomach, then, is constructed like that of animals without
674^b upper front teeth, and, its dental arrangements being such

[1] *G.A.* ii. 4. 740^a 21–^{b} 12 ; 6. 743^a 8 – 7. 746^a 28.
[2] Cf. iii. 12. 674^a 3 note.
[3] The camel has in fact two incisor teeth in the upper jaw. But these are placed laterally close against the canines, so as to leave a considerable vacant space in the front of the mouth. Had A. known of the existence of these upper incisors, he would not have failed to find in their presence a striking confirmation of his views as to the inverse development of teeth and horns. Cf. iii. 2. 664^a 1.

as to match its stomach, the teeth in question are wanting. They would indeed be of no service. Its food, moreover, being of a thorny character, and its tongue necessarily made of a fleshy substance, nature uses the earthy matter which is saved from the teeth to give hardness to the palate. The camel ruminates like the horned animals, because its multiple stomach resembles theirs. For all animals that have horns, the sheep for instance, the ox, the goat, the deer, and the like, have several stomachs. For since the mouth, owing to its lack of teeth, only imperfectly performs its office as regards the food, this multiplicity of stomachs is intended to make up for its shortcomings; the several cavities receiving the food one from the other in succession; the first taking the unreduced substances, the second the same when somewhat reduced, the third when reduction is complete, and the fourth when the whole has become a smooth pulp. Such is the reason why there is this multiplicity of parts and cavities in animals with such dentition. The names given to the several cavities are the paunch, the honey-comb bag, the manyplies, and the reed. How these parts are related to each other, in position and in shape, must be looked for in the treatises on Anatomy and the Researches concerning Animals.[1]

Birds also present variations in the part which acts as a recipient of the food; and the reason for these variations is the same as in the animals just mentioned. For here again it is because the mouth fails to perform its office and fails even more completely — for birds have no teeth at all, nor any instrument whatsoever with which to comminute or grind down their food—it is, I say, because of this, that in some of them what is called the crop precedes the stomach and does the work of the mouth; while in others the oesophagus is either wide throughout[2] or a part of it bulges

[1] Cf. *H. A.* ii. 17. 507a 34–b 15.

[2] The oesophagus, as a general rule, is wide and dilatable in birds, 'in correspondence with the imperfection of the oral instruments as comminutors of the food' (Owen). It is especially wide in the cormorant and other fishing birds. A. (*H. A.* ii. 17. 508b 35) gives as examples several species of crows, with which he appears (*H. A.* viii. 3. 593b 18) to have classed the cormorant.

just before it enters the stomach, so as to form a preparatory store-house for the unreduced food;[1] or the stomach itself has a protuberance in some part,[2] or is strong and fleshy,[3] so as to be able to store up the food for a considerable period and to concoct it, in spite of its not having been ground into a pulp. For nature retrieves the inefficiency of the mouth by increasing the efficiency and heat of the stomach. Other birds there are, such, namely, as have long legs and live in marshes, that have none of these provisions, but merely an elongated oesophagus.[4] The explanation of this is to be found in the moist character of their food. For all these birds feed on substances easy of reduction, and their food being moist and not requiring much concoction, their digestive cavities are of a corresponding character.

675a Fishes are provided with teeth, which in almost all of them[5] are of the sharp interfitting kind. For there is but one small section in which it is otherwise. Of these the fish called Scarus (*Parrot-fish*) is an example. And this is probably the reason why this fish apparently ruminates,

[1] Alluding to the *proventriculus* or glandular stomach. This exists in all birds, but is much larger and more glandular when there is no crop, than when this is present. Doubtless in such cases it supplies the absence of the crop (Cuvier, *Leçons*, iii. 408), and acts as a store-house of food.

[2] The example given in the *H. A.* (ii. 17. 509a 6) is a bird which Aubert and Wimmer identify with *Falco tinnunculus*. They point out that in all the diurnal birds of prey there is a peculiarity, thus described by Meckel (*Tr. Gén. d'Anat. Comp.* viii. 314): 'L'estomac folliculeux d'une ampleur peu considérable forme subitement une saillie allongée, qui est séparée par un étranglement, supérieurement de l'œsophage, et inférieurement de l'estomac musculaire.'

[3] The gizzard is strong and muscular in graminivorous birds; but thin and membranous in the carnivorous species.

[4] In the Greek text, instead of oesophagus (στόμαχος) we have crop (πρόλοβος). This must be an error; for the presence of a crop is one of the very provisions which A. has just enumerated, and which he says are wanting in the long-legged marsh-birds, i. e. the Grallatores. I therefore read στόμαχος for πρόλοβος; which is in harmony with the parallel passage in the *Hist. An.* (ii. 17. 509a 9), where it is said that these birds have a long oesophagus to match their long neck.

In the typical waders there is no crop; neither is the stomach fleshy, but has thin walls, as in piscivorous birds generally. The 'dilatation of the oesophagus before it enters the stomach', i. e. the *proventriculus*, would also seem to A. to be absent; for it forms one single cavity with the thin-walled gizzard; at least such is the case in the heron (Cuvier, *Leçons*, iii. 410).

[5] For πάντας read πάντες.

though no other fishes do so.[1] For those horned animals that have no front teeth in the upper jaw also ruminate.

In fishes the teeth are all[2] sharp; so that these animals can divide[3] their food, though imperfectly. For it is impossible for a fish to linger or spend time in the act of mastication, and therefore they have no teeth that are flat or suitable for grinding; for such teeth would be to no purpose. The oesophagus again in some fishes is entirely wanting, and in the rest is but short. In order, however, to facilitate the concoction of the food, some of them, as the Cestreus[4] (*mullet*), have a fleshy stomach resembling that of a bird; while most of them have numerous processes close against the stomach, to serve as a sort of antechamber in which the food may be stored up and undergo putrefaction[5] and concoction. There is a contrast between fishes and birds in the position of these processes. For in fishes they are placed close to the stomach; while in birds, if present at all, they are lower down, near the end of the gut.[6] Some of the Vivipara also have processes connected with

[1] Whether the parrot-fish ruminates I do not know; but A. is wrong in saying that no other fish does so. There are several species, especially of the carp tribe, in which a sort of rumination occurs. Cf. Owen, *Comp. Anat.* ii. 236.

[2] For πάντες read πάντας.

[3] Cf. iii. 1. 662^{a} 13. The sharp teeth of fishes, however, serve rather for the retention than for the mastication of food.

[4] The Cestreus is doubtless some species of Mugil, a tribe of which our grey mullet is a familiar example. What species is meant is uncertain; the Mediterranean containing at least five. In all these Mugilidae the stomach has much the character of a true muscular gizzard. 'Of all the fish I have seen, the mullet is the most complete instance of this (the grinding) structure; its strong muscular stomach being evidently adapted, like the gizzard of birds, to the two offices of mastication and digestion.'—John Hunter.

[5] A. seems here to admit that digestion is in part due to putrefaction, a doctrine held by Pleistonicus.

[6] In most osseous fishes, though not in all, there are a variable number of caecal appendages close behind the pylorus, which have been erroneously held to be the homologues of the pancreas. Their use is not known with certainty. The Selachia are rightly stated by A. (*H. A.* ii. 17. 508^{b} 22) to be without these caeca. In birds, as a rule, there are two caeca at the junction of small and large gut; rarely, as in the heron, a single caecum. Sometimes, however, as A. notices here and elsewhere (*H. A.* ii. 17. 508^{b} 14), the caeca are absent. This is the case, for instance, in the wryneck, woodpecker, lark, and cormorant, among birds known to Aristotle.

the lower part of the gut[1] which serve the same purpose as that stated above.

The whole tribe of fishes is of gluttonous appetite, owing to the arrangements for the reduction of their food being very imperfect, and much of it consequently passing through them without undergoing concoction; and, of all, those are the most gluttonous that have a straight intestine. For as the passage of food in such cases is rapid, and the enjoyment derived from it in consequence but brief, it follows of necessity that the return of appetite is also speedy.[2]

It has already been mentioned that in animals with front teeth in both jaws the stomach is of small size.[3] It may be classed pretty nearly always under one or other of two headings, namely as resembling the stomach of the dog, or as resembling the stomach of the pig. In the pig the stomach is larger than in the dog, and presents certain folds of moderate size, the purpose of which is to lengthen out the period of concoction; while the stomach of the dog is of small size, not much larger in calibre than the gut, and smooth on the internal surface.[4]

Not much larger, I say, than the gut; for in all animals after the stomach comes the gut. This, like the stomach, presents numerous modifications. For in some animals it is uniform, when uncoiled, and alike throughout, while in

[1] Meaning of course the caecum and vermiform appendix. There is the greatest variety in the different mammalian orders as to the presence or absence of these. Cf. Cuvier, *Leçons*, iii. 465.

[2] Fishes, says A., do not digest their food well, because they have a short gut; and so they are ravenous. Similarly in the *Timaeus* it is said that a long intestine was given to animals to prevent insatiable gluttony. An abnormally short gut is, in fact, a sufficient cause for a ravenous appetite (cf. Schiff, *Sur la Digestion*, i. 44). The normally short gut of a fish is, however, probably to be explained by the easy digestibility of their food.

[3] What he stated before was that they had a single stomach, not a small one. The single stomach is, however, small as compared with the multiple stomach of the ruminants.

[4] The stomach of the dog, as of Carnivora generally, is of small size, somewhat elongated, and perfectly smooth within. That of the pig is of larger dimensions owing to the very ample cardiac cul-de-sac, is of globular shape, and presents on its internal surface two transverse folds on either side of the cardia. Cf. *H.A.* ii. 17. 507b 19. The two types, then, under which A. classes stomachs are the small, perfectly simple stomach of Carnivora, and the larger and less simple stomach that, beginning with the pig, culminates in the very complicated organ of the ruminants. Cf. Owen, *Anat. of Vert.* iii. 463.

others it differs in different portions. Thus in some cases it is wider in the neighbourhood of the stomach, and narrower towards the other end; and this explains by the way why dogs[1] have to strain so much in discharging their excrement. But in most animals it is the upper portion that is 675b the narrower and the lower that is of greater width.

Of greater length than in other animals, and much convoluted, are the intestines of those that have horns.[2] These intestines, moreover, as also the stomach, are of ampler volume, in accordance with the larger size of the body. For animals with horns are, as a rule, animals of no small bulk, because of the thorough elaboration which their food undergoes. The gut, except in those animals[3] where it is straight, invariably widens out as we get farther from the stomach and come to what is called the colon, and to a kind of caecal dilatation. After this it again becomes narrower and convoluted.[4] Then succeeds a straight portion which runs right on to the vent. This vent is known as the anus, and is in some animals surrounded by fat, in others not so. All these parts have been so contrived by nature as to harmonize with the various operations that relate to the food and its residue. For, as the residual food gets farther on and lower down, the space to contain it enlarges, allowing it to remain stationary and undergo conversion. Thus is it in those animals which, owing either to their large size, or to the heat of the parts concerned,[5] require more nutriment, and consume more fodder than the rest.

[1] 'Dans les chiens . . . . les gros intestins n'ont guères plus de diamètre que les grêles.' Cuvier, *Leçons*, iii. 485.

[2] The intestines, longer in Herbivora generally than in Carnivora, attain the greatest length in ruminants. In the sheep, for instance, they are twenty-eight times as long as the body; in the equally herbivorous but non-ruminating rabbit ten times; in the carnivorous dog only five times.

[3] What animals, if any, at all comparable with ruminants, A. held to have a straight intestine, I cannot surmise. Here, however, he seems to include all non-ruminants under εὐθυέντερα, as being comparatively straight-gutted. Cf. *H. A.* ii. 17. 507b 34.

[4] Referring to the spiral coil of the colon, which forms one of the characteristics of the Artiodactyla (cf. Owen, *Vert.* iii. 474). The colon becomes narrower where it assumes this spiral disposition. Later on A. calls this part the coil or helix (ἕλιξ). The straight terminal part is of course the rectum.

[5] The digestive cavities. As to τόπων compare τῶν τόπων ἀμφοτέρων, 676a 2.

Neither is it without a purpose that, just as a narrower gut succeeds to the upper stomach, so also does the residual food, when its goodness is thoroughly exhausted, pass from the colon and the ample space of the lower stomach into a narrower channel and into the spiral coil. For so nature can regulate her expenditure and prevent the excremental residue from being discharged all at once.[1]

In all such animals, however, as have to be comparatively moderate in their alimentation,[2] the lower stomach presents no wide and roomy spaces, though their gut is not straight, but has a number of convolutions. For amplitude of space causes desire for ample food, and straightness of the intestine causes quick return of appetite. And thus it is that all animals whose food receptacles are either simple or spacious are of gluttonous habits, the latter eating enormously at a meal, the former making meals at short intervals.

Again, since the food in the upper stomach, having just been swallowed, must of necessity be quite fresh, while that which has reached the lower stomach must have had its juices exhausted and resemble dung, it follows of necessity that there must also be some intermediate part, in which the change may be effected, and where the food will be neither perfectly fresh nor yet dung. And thus it is that, in all such animals as we are now considering, there is found what is called the jejunum;[3] which is a part of the small gut, of the gut, that is, which comes next to the stomach. For this jejunum lies between the upper cavity which contains the yet unconcocted food and the lower cavity which holds the residual matter, which by the time it has got here has become worthless. There is a jejunum in all these
676a animals, but it is only plainly discernible in those of large size, and this only when they have abstained from food for

[1] Why should she do so? A. probably has in mind the Bonasus (iii. 2. 663a 16).

[2] That is, the Carnivora; whose food is only taken at comparatively long intervals (iv. 10. 688b 4) and is not so bulky as that of Herbivora. In these the gut, though not unconvoluted, is less so than in ruminants, of which animals A. has up to now been speaking, and is without their spiral coil or their capacious caecum and colon.

[3] Jejunum (*νῆστις*) is the name given to the middle section of the small intestine, because it is usually found empty after death. The passage of the contained food through it takes place with great rapidity (cf. M. Edwards, *Leçons*, iii. 130).

a certain time. For then alone can one hit on the exact period when the food lies half-way between the upper and lower cavities; a period which is very short, for the time occupied in the transition of food is but brief. In females this jejunum may occupy any part whatsoever of the upper intestine, but in males it comes just before the caecum and the lower stomach.[1]

15 What is known as rennet[2] is found in all animals that have a multiple stomach, and in the hare[3] among animals whose stomach is single. In the former the rennet neither occupies the large paunch, nor the honeycomb bag, nor the terminal reed, but is found in the cavity which separates this terminal one from the two first, namely in the so-called manyplies.[4] It is the thick character of their milk which causes all these animals to have rennet; whereas in animals with a single stomach the milk is thin, and consequently no rennet is formed. It is this difference in thickness[5] which makes the milk of horned animals coagulate, while that of animals without horns does not. Rennet forms in the hare because it feeds on herbage that has juice like that of the fig;[6] for juice of this kind coagulates the milk in the stomach of the sucklings.[7] Why it is in the manyplies that rennet is formed in animals with multiple stomachs has been stated in the Problems.[8]

[1] This strange statement has no anatomical foundation.

[2] By rennet is usually meant the wall of the fourth stomach of a sucking ruminant, which contains a substance that has the property of coagulating milk; but the term is also used for the milk when thus coagulated, which, owing to the substance mixed with it, has the power of coagulating other milk. It is this concreted milk that A. calls rennet, attributing its formation to that convenient agent 'Vital heat' (*G. A.* ii. 4. 739b 23; *H. A.* iii. 21. 522b 7).

[3] So also Varro (*De Re rustica*, ii. 11).

[4] This is erroneous. It is the fourth stomach that gives rennet.

[5] The thickness of milk, as explained in *H. A.* iii. 20. 521b 28, depends on the proportion of cheese it contains as compared with the whey. The milk of ruminants is rightly stated to contain much more cheese, i. e. caseine, than that of other animals.

[6] The leaves of the common Pinguicula contain a juice which has the power of coagulating milk, and is said by Linnaeus to be used by the Laplanders in the fabrication of cheese. The same property is possessed by *Galium Verum*, sometimes therefore called Cheese Rennet. As to fig-juice cf. *H. A.* iii. 20. 522b 2.

[7] Ἔμβρυον seems a strange term for a suckling which not only sucks but grazes. Cf. *Odyssey* ix. 245.

[8] Not in the Problems as they have come down to us.

BOOK IV

THE account which has now been given of the viscera,[1] I
the stomach, and the other several parts holds equally good not only for the oviparous quadrupeds, but also for such apodous animals as the Serpents. These two classes of animals are indeed nearly akin, a serpent resembling a lizard which has been lengthened out and deprived of its feet. Fishes, again, resemble these two groups in all their parts, excepting that, while these, being land animals, have a lung, fishes have no lung, but gills in its place. None of these animals, excepting the tortoise, as also no fish, has a urinary bladder.[2] For owing to the bloodlessness of their lung, they drink but sparingly; and such fluid as they have is diverted to the scaly plates, as in birds it is diverted to the feathers, and thus they come to have the same white matter on the surface of their excrement as we see on that of birds. For[3] in animals that have a bladder, its excretion when voided throws down a deposit of earthy brine in the containing vessel.[4] For the sweet and fresh elements, being light, are expended on the flesh.

676b Among the Serpents, the same peculiarity attaches to vipers, as among fishes attaches to Selachia. For both these and vipers are externally viviparous, but previously produce ova internally.[5]

[1] The stomach is not one of the viscera in A.'s sense. Cf. iii. 4. 665a 31 note.

[2] Cf. iii. 8. 671b 15 note.

[3] For διόπερ read διότι.

[4] And this earthy brine, it is implied, must, if there is no bladder, be discharged by the bowel. It is, of course, discharged with the faecal matter from the reptilian and avian cloaca.

[5] A. includes under Selachia all cartilaginous fishes, among which he erroneously classes the Lophius (cf. iv. 13. 695b 14 note). All these, he often says, with the exception of Lophius, are ovoviviparous: that is, they retain their ova within the body till hatched. In some of these ovovivipara the embryo throughout remains free from all anatomical connexion with the mother, but in some, when the nutriment supplied by the yelk is exhausted, the embryo forms a connexion with the parent's body (*G. A.* ii. 4. 727b 23; iii. 3. 754b 27). The latter part of

The stomach in all these animals is single, just as it is single in all other animals that have teeth in front of both jaws; and their viscera are excessively small, as always happens when there is no bladder. In serpents these viscera are, moreover, differently shaped from those of other animals. For, a serpent's body being long and narrow, its contents are as it were moulded into a similar form, and thus come to be themselves elongated.

All animals that have blood possess an omentum, a mesentery,[1] intestines with their appendages, and, moreover, a diaphragm and a heart; and all, excepting fishes, a lung and a windpipe. The relative positions, moreover, of the windpipe and the oesophagus are precisely similar in them all; and the reason is the same as has already been given.[2]

2 Almost all sanguineous animals have a gall-bladder. In some this is attached to the liver, in others separated from that organ[3] and attached to the intestines, being apparently in the latter case no less than in the former an appendage of the lower stomach.[4] It is in fishes that this is most

this statement applies to certain sharks, which do in fact present a rudimentary placenta. The former part of his statement is too wide a generalization; for the oviparous dogfishes and the rays present exceptions to the statement that all A.'s Selachia are, as he says, ovo-viviparous. Yet A. (*H. A.* vi. 10. 565a 22) was well acquainted with the eggs of the dogfishes and the rays. The explanation seems to be that he imagined that the young fish was fully developed in the ovum at the time when this was first laid. It is, however, very doubtful whether this is the case, unless as an exception. Cf. Meyer, *Thierkunde*, p. 281.

The osseous fishes A. states to be all oviparous. This rule, however, is not without exception; e. g. the viviparous blenny.

[1] All vertebrata have a mesentery, with the exception of the lamprey, the carp, and some other fishes, and even these have it in their embryonic stage. As to the omentum, cf. iv. 3. 677b 23 note; as to the diaphragm, cf. iii. 10. 672b 13 note.

[2] Cf. iii. 3. 664b 3, where, however, the inconvenient position is described, but no explanation proffered.

[3] In certain Ophidia the gall-bladder is, in fact, completely separated from the liver and lies close to the pylorus. This is so in all the serpents that have the tongue enclosed in a sheath (Duvernoy, *Ann. d. Sc. Nat.* xxx. 127). A similar condition is found in some fishes (Owen, *Lect. on Comp. An.* ii. 243), among others in the Lophius, the Swordfish, and the Muraena; all of which are elsewhere (*H. A.* ii. 15. 506b 15) enumerated as examples of this structure. Probably this peculiar arrangement has reference to the long narrow shape of the animals, and exists for convenience of packing.

[4] As to lower stomach, cf. ii. 3. 650a 14 note; iii. 14. 675b 19. The

clearly seen. For all fishes [1] have a gall-bladder; and in most of them it is attached to the intestine, being in some, as in the Amia,[2] united with this, like a border, along its whole length. It is similarly placed in most serpents. There are therefore [3] no good grounds for the view entertained by some writers, that the gall exists for the sake of some sensory action. For they say that its use is to affect that part of the soul which is lodged in the neighbourhood of the liver, vexing this part when it is congealed, and restoring it to cheerfulness when it again flows free. But this cannot be. For in some animals there is absolutely no gall-bladder at all—in the horse, for instance, the mule, the ass, the deer, and the roe; and in others, as the camel, there is no distinct bladder, but merely small vessels of a biliary character. Again, there is no such organ in the seal, nor, of purely sea-animals, in the dolphin.[4] Even within the limits of the same genus, some animals appear to have and others to be without it.[5] Such, for instance, is the case with mice;

exact meaning of this passage is doubtful. I understand, however, A. to mean that the bile is in all cases discharged into the intestine at a point below the upper or true stomach.

[1] Fishes are very rarely without a gall-bladder, though there are some few exceptions, e. g. sawfish, lamprey, and basking-shark.

[2] The Amia appears to be the *Scomber Sarda* of Cuvier. This fish abounds in the Mediterranean. Like the tunny, bonito, and sundry other Scombridae, it is remarkable for the extreme length and slenderness of its gall-bladder. Cuvier, *Règ. Anim.* ii. 199, and Owen, *Lect.* ii. 244.

[3] This very obscure and corrupt passage is intended to summarize Plato's views as to the gall as given in the *Timaeus* 71. For συνιστῇ read συστῇ.

[4] A. is correct in this enumeration of animals that have no gall-bladder, with the exception of the seal. The *Phoca vitulina* has a gall-bladder; but it may possibly, though improbably, be that the *Phoca monachus*, which was the species best known to the ancients (Cuvier, *Règne An.* i. 169), is without one, as Frantzius suggests.

[5] The gall-bladder is sometimes present, sometimes absent in giraffes (Owen-Joly); in the apteryx and bittern (Owen); in the guinea-fowl, &c. It is especially variable, as A. rightly says, in the different species of Mus (Cuvier, *Leçons*, iv. 36). In man a congenital absence of the gall-bladder has been noticed in rare instances (Rokitansky, ii. 155; *Phil. Trans.* 1749). This, however, could not be known to A., who says, moreover (*H. A.* i. 17. 496b 22), that *most* men are without a gall-bladder. If, as is not impossible, A. examined aborted human embryos, he might easily have been led to this erroneous opinion. For the gall-bladder is not developed at all until the third month, at a time when the liver almost entirely fills the abdominal cavity.

such also with man. For in some individuals there is a distinct gall-bladder attached to the liver, while in others there is no gall-bladder at all. This explains how the existence of this part in the whole genus has been a matter of dispute. For each observer, according as he has found it present or absent in the individual cases he has examined, has supposed it to be present or absent in the whole genus. The same has occurred in the case of sheep and of goats. For these animals usually have a gall-bladder; but, while in some 677a
localities it is so enormously big as to appear a monstrosity, as is the case in Naxos, in others it is altogether wanting, as is the case in a certain district belonging to the inhabitants of Chalcis in Euboea.[1] Moreover, the gall-bladder in fishes is separated, as already mentioned,[2] by a considerable interval from the liver.[3] No less mistaken seems to be the opinion of Anaxagoras and his followers, that the gall-bladder is the cause of acute diseases, inasmuch as it becomes over-full, and spirts out its excess on to the lung, the blood-vessels, and the ribs. For, almost invariably, those who suffer from these forms of disease are persons who have no gall-bladder at all, as would be quite evident were they to be dissected. Moreover, there is no kind of correspondence between the amount of bile which is present in these diseases and the amount which is exuded.[4] The most probable opinion is that, as the bile when it is present in any other part of the body is a mere residuum or a product of decay, so also when it is present in the region of the liver it is equally excremental and has no further use; just as is the case with the dejections of the stomach and intestines. For though even the residua are occasionally used by nature for some useful purpose, yet we must not in all cases expect to find such a final cause; for granted the existence in the body of this or that constituent, with such

[1] Cf. *H. A.* i. 17. 496b 26.

[2] Cf. iv. 2. 676b 19.

[3] And therefore cannot have the action these writers attribute to it.

[4] When an animal's body is opened some time after death, the parts near the gall-bladder are often found to be stained yellow from an exudation of bile. It is probably to this overflow that reference is made, as being excessively small in comparison with the amount of bile which is apparent in the human body in cases of jaundice.

and such properties, many results must ensue merely as necessary consequences of these properties. All animals, then, whose liver is healthy in composition and supplied with none but sweet blood, are either entirely without a gall-bladder on this organ, or have merely small bile-containing vessels ; or are some with and some without such parts. Thus it is that the liver in animals that have no gall-bladder is, as a rule, of good colour and sweet ; and that, when there is a gall-bladder, that part of the liver is sweetest which lies immediately underneath it. But, when animals are formed of blood less pure in composition, the bile serves for the excretion of its impure residue. For the very meaning of excrement is that it is the opposite of nutriment, and of bitter that it is the opposite of sweet ; and healthy blood is sweet. So that it is evident that the bile, which is bitter, cannot have any useful end, but must simply be a purifying excretion. It was therefore no bad saying of old writers that the absence of a gall-bladder gave long life. In so saying they had in mind deer and animals with solid hoofs. For such have no gall-bladder and live long. But besides these there are other animals that have no gall-bladder, though those old writers had not noticed the fact, such as the camel and the dolphin ; and these also are, as it happens, long-lived.[1] Seeing, indeed, that the liver is not only useful, but a necessary and vital part in all
677b animals that have blood, it is but reasonable that on its character should depend the length or the shortness of life. Nor less reasonable is it that this organ and none other should have such an excretion as the bile. For the heart, unable as it is to stand any violent affection, would be utterly intolerant of the proximity of such a fluid ; and, as to the rest of the viscera, none excepting the liver are necessary parts of an animal. It is the liver therefore that alone has this provision. In conclusion, wherever we see bile we must take it to be excremental. For to suppose

[1] The camel is said by A. (*H. A.* viii. 9. 596^a 10) to live for 30 years, and exceptionally for 100 years. Burckhardt gives it a life of 40 years. As to the dolphin it is stated (*H. A.* vi. 12. 566^b 24) that some had been marked by fishermen and let go ; and that by their recapture it had been ascertained that they live at least 30 years.

that it has one character in this part, another in that, would be as great an absurdity as to suppose mucus or the dejections of the stomach to vary in character according to locality and not to be excremental wherever found.

3 So much then of the gall-bladder, and of the reasons why some animals have one, while others have not. We have still to speak of the mesentery and the omentum; for these are associated with the parts already described and contained in the same cavity. The omentum, then, is a membrane containing fat; the fat being suet or lard, according as the fat of the animal generally is of the former or latter description. What kinds of animals are so distinguished has been already set forth in an earlier part of this treatise.[1] This membrane, alike in animals that have a single and in those that have a multiple stomach, grows from the middle of that organ, along a line which is marked on it like a seam. Thus attached, it covers the rest of the stomach and the greater part of the bowels, and this alike in all sanguineous animals, whether they live on land or in water.[2] Now the development of this part into such a form as has been described is the result of necessity. For, whenever solid and fluid are mixed together and heated, the surface invariably becomes membranous and skin-like. But the region in which the omentum lies is full of nutriment of such a mixed character. Moreover, in consequence of the close texture of the membrane, that portion of the sanguineous nutriment will alone filter into it which is of a greasy character; for this portion is composed of the finest particles; and when it has so filtered in, it will be concocted by the heat of the part, and will be converted into suet or lard, and will not acquire a flesh-like or sanguineous constitution. The development, then, of the omentum is simply the result of necessity. But when once formed, it is used by nature for an end, namely, to facilitate and to hasten the concoction of food. For all that is hot aids concoction; and fat is hot, and the omentum is fat. This too explains why it hangs

[1] Cf. ii. 5. 657[a] 35.

[2] A similar statement is made elsewhere (iv. 1. 676[b] 11; *H. A.* iii. 14). It is, however, erroneous. Mammalia alone have an omentum.

from the middle of the stomach; for the upper part of the stomach has no need of it, being assisted in concoction by the adjacent liver. Thus much as concerns the omentum.

The so-called mesentery is also a membrane; and extends continuously from the long stretch of intestine to the 4
678a great vessel and the aorta. In it are numerous and close-packed vessels, which run from the intestines to the great vessel and to the aorta. The formation of this membrane we shall find to be the result of necessity, as is that of the other [similar] parts.[1] What, however, is the final cause of its existence in sanguineous animals is manifest on reflection. For it is necessary that animals shall get nutriment from without; and, again, that this shall be converted into the ultimate nutriment, which is then distributed as sustenance to the various parts; this ultimate nutriment being, in sanguineous animals, what we call blood, and having, in bloodless animals, no definite name. This being so, there must be channels through which the nutriment shall pass, as it were through roots, from the stomach into the blood-vessels. Now the roots of plants are in the ground; for thence their nutriment is derived. But in animals the stomach and intestines represent the ground from which the nutriment is to be taken. The mesentery, then, is an organ to contain the roots; and these roots are the vessels that traverse it. This then is the final cause of its existence. But how it absorbs nutriment, and how that portion of the food which enters into the vessels is distributed by them to[2] the various parts of the body, are questions which will be considered when we come to deal with the generation and nutrition of animals.

The constitution of sanguineous animals, so far as the parts as yet mentioned are concerned, and the reasons for such constitution, have now been set forth. In natural sequence we should next go on to the organs of generation, as yet undescribed, on which depend the distinctions of male and female. But, inasmuch as we shall have to deal spe-

[1] A. cannot have meant that all the parts are the necessary outcome of purely physical conditions, but only that membranes (*G. A.* ii. 4. 739b 27) so originate. Either τοιούτοις must be supplied before μορίοις or for μορίοις may be read ὑμέσιν (Platt).

[2] For ταῦτα read πάντα.

cially with generation hereafter, it will be more convenient to defer the consideration of these parts to that occasion.

5 Very different from the animals we have as yet considered are the Cephalopoda and the Crustacea. For these have absolutely no viscera[1] whatsoever; as is indeed the case with all bloodless animals, in which are included two other genera, namely the Testacea and the Insects. For in none of them does the material out of which viscera are formed exist. None of them, that is, have blood. The cause of this lies in their essential constitution. For the presence of blood in some animals, its absence from others, must be included in the conception which determines their respective essences. Moreover, in the animals we are now considering, none of those final causes will be found to exist which in sanguineous animals determine the presence of viscera. For they have no blood-vessels nor urinary bladder,[2] nor 678^{b}
do they breathe; the only part that it is necessary for them to have being that which is analogous to a heart. For in all animals there must be some central and commanding part of the body, to lodge the sensory portion of the soul and the source of life. The organs of nutrition are also of necessity present in them all. They differ, however, in character because of differences of the habitats in which they get their subsistence.

In the Cephalopoda there are two teeth,[3] enclosing what is called the mouth; and inside this mouth is a flesh-like substance which represents a tongue and serves for the discrimination of pleasant and unpleasant food. The Crustacea have teeth corresponding to those of the Cephalopoda, namely their anterior teeth,[4] and also have the fleshy repre-

[1] Cf. iii. 4. 665^{a} 31 note.

[2] Urinary bladder and lung (iii. 8. 671^{a} 1) were to A. signs of abundant blood; and viscera (iii. 7. 670^{a} 8 note) were one of the channels by which superfluous blood was eliminated.

[3] By the teeth are meant the two halves of the parrot-like beak. The so-called tongue is a large organ, and its anterior part 'very soft in texture, beset with numerous papillae, having all the characters of a perfect organ of taste' (Owen).

[4] The 'anterior teeth' are the strong shear-like mandibles; which are called anterior to distinguish them from the stomachal teeth presently to be mentioned. By the tongue is meant the bifid lower lip, which has been called a tongue by other writers than A., but is not properly comparable to such an organ. Cf. Todd, *Cycl.* i. 773.

sentative of a tongue. This latter part is found, moreover, in all Testacea,[1] and serves, as in sanguineous animals, for gustatory sensations. Similarly provided also are the Insects. For some of these, such as the Bees and the Flies, have, as already described,[2] their proboscis protruding from the mouth; while those others that have no such instrument in front have a part which acts as a tongue inside the mouth.[3] Such, for instance, is the case in the Ants and the like. As for teeth, some insects have them, the Bees and the Ants[4] for instance, though in a somewhat modified form, while others that live on fluid nutriment are without them. For in many insects the teeth are not meant to deal with the food, but to serve as weapons.

In some Testacea, as was said in the first treatise,[5] the organ which is called the tongue is of considerable strength; and in the Cochli (*Sea-snails*) there are also two teeth,[6] just as in the Crustacea. The mouth in the Cephalopoda is succeeded by a long gullet. This leads to a crop,[7] like that of a bird, and directly continuous with this is the stomach, from which a gut runs without windings to the vent. The Sepias and the Poulps resemble each other completely, so far as regards the shape and consistency of these parts. But not so the Teuthides (*Calamaries*). Here, as in the other groups, there are the two stomach-like receptacles; but the

[1] The tongue or odontophore forms a very remarkable organ in the Gasteropoda, but there is none in the Conchifera or bivalves of Aristotle.

[2] Cf. *H. A.* iv. 4. 528b 29.

[3] The so-called 'tongue' of insects is the upper portion of the labium, and is very distinct in some species. In bees and flies this tongue goes, with the rest of the labium, to form what A. calls their proboscis; so that it is only in other insects that there is a distinct tongue inside the mouth.

[4] Reading μυρμήκων for μυιῶν, the very probable emendation of Meyer. The 'modified teeth' are the mandibles. The insects that live on fluid nutriment and have no teeth are the Lepidoptera, in which the maxillae are converted into a long proboscis, while the mandibles are quite rudimentary.

[5] *H. A.* iv. 4. 528b 33.

[6] i. e. the horny jaws with which some Gasteropods are furnished.

[7] By the crop (πρόλοβος) and stomach of the Cephalopoda A. meant respectively what modern anatomists recognize as the stomach and the first part of the intestine; which latter is dilated and has a diverticulum that in some species is spirally convoluted so as to be aptly likened by A. (*H. A.* iv. 1. 524b 11) to the helix of a whelk. The real crop, which is present only in the poulps among dibranchiate Cephalopoda, was not noticed by A.

first of these cavities has less resemblance to a crop, and in neither is the form [or the consistency] the same as in the other kinds, the whole body indeed being made of a softer kind of flesh.

The object of this arrangement of the parts in question is the same in the Cephalopoda as in Birds; for these also are all unable to masticate their food; and therefore it is that a crop precedes their stomach.

For purposes of defence, and to enable them to escape from their foes, the Cephalopoda have what is called their ink. This is contained in a membranous pouch, which is 679a
attached [1] to the body and provided with a terminal outlet just at the point where what is termed the funnel gives issue to the residua of the stomach. This funnel is placed on the ventral surface of the animal. All Cephalopoda alike have this characteristic ink, but chief of all the Sepia, where it is more abundant than in the rest. When the animal is disturbed and frightened it uses this ink to make the surrounding water black and turbid, and so, as it were, puts a shield in front of its body.

In the Calamaries and the Poulps the ink-bag is placed in the upper part of the body, in close proximity to the *mytis*,[2] whereas in the Sepia it is lower down, against the stomach. For the Sepia has a more plentiful supply of ink than the rest, inasmuch as it makes more use of it. The reasons for this are, firstly, that it lives near the shore, and, secondly, that it has no other means of protection; whereas the Poulp has its long twining feet to use in its defence, and is, moreover, endowed with the power of changing colour.[3] This changing of colour, like the discharge of ink, occurs as

[1] For προσπεφυκότα read προσπεφυκότι.

[2] The *mytis* is identical with the *mecon*, which exists in all Crustacea (*H. A.* iv. 2. 526b 32); is a bag containing excretory matter (*H. A.* iv. 4. 529b 11); placed (680a 23) near the hinge in bivalves, and in the spiral part of the shell in Turbinata, being spiral itself, in the whelk for instance (*H. A.* iv. 4. 529a 10). This can be nothing else than the liver; and Köhler's notion that the glandular appendages of the veins are meant (Todd, *Cycl. of An. and Phy.* i. 539) is out of the question.

[3] In reality all these Cephalopods have the faculty of changing colour; but the phenomenon is most conspicuous in the poulps (cf. Cuvier, *R. An.* iii. 10).

the result of fright. As to the Calamary, it lives far out at sea, being the only one of the Cephalopoda that does so;[1] and this gives it protection. These then are the reasons why the ink is more abundant in the Sepia than in the Calamary, and this greater abundance explains the lower position; for it allows the ink to be ejected with ease even from a distance. The ink itself is of an earthy character, in this resembling the white deposit[2] on the surface of a bird's excrement, and the explanation in both cases is the same, namely, the absence of a urinary bladder. For, in default of this, it is the ink that serves for the excretion of the earthiest matter. And this is more especially the case in the Sepia, because there is a greater proportion of earth in its composition than in that of the other Cephalopoda. The earthy character of its bone is a clear indication of this. For in the Poulp there is no bone at all, and in the Calamary it is thin and cartilaginous. Why this bone should be present in some Cephalopoda, and wanting in others, and how its character varies in those that have it, has now been set forth.[3]

These animals, having no blood, are in consequence cold and of a timid character. Now, in some animals, fear causes a disturbance of the bowels, and, in others, a flow of urine from the bladder. Similarly in these it produces a discharge of ink, and, though the ejection of this ink in fright, like that of the urine, is the result of necessity, and, though it is of excremental character, yet it is used by nature for a purpose, namely, the protection and safety of the animal that excretes it.

The Crustacea also, both the Caraboid forms and the Crabs, are provided with teeth, namely their two anterior teeth; and between these they also present the tongue-like piece of flesh, as has indeed been already mentioned.[4] Directly after their mouth comes a gullet, which, if we compare relative sizes, is but small in proportion to the body:

[1] The Sepiadae, and still more the Calamaries, are pelagic; the Poulps are littoral.

[2] Cf. iv. 1. 676a 32.

[3] Or εἴρηται πρότερον (P), in which case the reference is to ii. 8. 654a 20.

[4] Cf. 678b 10.

and then a stomach, which in the Carabi and some of the Crabs is furnished with a second set of teeth, the anterior teeth being insufficient for adequate mastication. From 679b
the stomach a uniform gut runs in a direct line to the excremental vent.[1]

The parts described are to be found also in all the various Testacea. The degree of distinctness, however, with which they are formed varies in the different kinds, and the larger the size of the animal the more easily distinguishable are all these parts severally. In the Sea-snails, for example, we find teeth, hard and sharp, as before mentioned,[2] and between them the flesh-like substance, just as in the Crustacea and Cephalopoda, and again the proboscis,[3] which, as has been stated,[4] is something between a sting and a tongue. Directly after the mouth comes a kind of bird-like crop,[5] then a gullet, succeeded by a stomach, in which is the *mecon*,[6] as it is styled; and continuous with this *mecon* is an intestine, starting directly from it. It is this residual substance which appears in all the Testacea to form the most palatable morsel. Purpuras and Whelks, and all other Testacea that have turbinate shells, in structure resemble the Sea-snail. The genera and species of Testacea are very

[1] The oesophagus in Crustacea is, as stated in the text, very short. The stomach-teeth are present in all Decapoda, and not only 'in the Carabi and some of the crabs'. The intestine is remarkably straight.

[2] Bronn (*Malacozoa*, part ii. 950), and Lebert (Müller's *Archiv*, 1846, p. 463), believe that A. means the lingual teeth. But these are almost too small to be seen with the naked eye. So Lebert boldly asserts that A. must have used a lens of glass or crystal, or some magnifying instrument! Clearly, however, the jaws are meant, not the lingual teeth: for they are said to be only two in number. Cf. iv. 5. 678b 23.

[3] In many Gasteropoda, especially the carnivorous species, there is a long retractile proboscis.

[4] Cf. *H. A.* iv. 4. 528b 30, where, however, nothing is said as to a sting.

[5] The crop, which comes directly after the mouth, is probably the 'buccal mass'; for the dilatation now called crop in many gasteropods (e. g. Dolium, Cypraea, Voluta) is as a rule removed from the mouth by half the length of oesophagus, though exceptionally (e. g. Turbo) it may be much nearer. Cf. Bronn, *Malacozoa*, part ii. 954).

[6] The *mecon* or *mytis* is the liver. This in Gasteropods is of great size and in most of them completely envelops the stomach and first part of the intestine, which latter therefore appears to start from it. When A. says that the *mecon* is inside the stomach he must have mistaken the outer surface of the visceral mass for the wall of the stomach.

numerous. For there are those with turbinate shells, of which some have just been mentioned; and, besides these, there are bivalves and univalves. Those with turbinate shells may, indeed, after a certain fashion be said to resemble bivalves. For they all from their very birth have an operculum to protect that part of their body which is exposed to view.[1] This is the case with the Purpuras, with Whelks, with the Nerites, and the like. Were it not for this, the part which is undefended by the shell would be very liable to injury by collision with external objects. The univalves also are not without protection. For on their dorsal surface they have a shell, and by the under surface they attach themselves to the rocks, and so after a manner become bivalved, the rock representing the second valve. Of these the animals known as Limpets are an example. The bivalves, scallops and mussels, for instance, are protected by the power they have of closing their valves; and the Turbinata by the operculum just mentioned, which transforms them, as it were, from univalves into bivalves. But of all there is none so perfectly protected as the sea-urchin. For here there is a globular shell which encloses the body completely, and which is, moreover, set with sharp spines. This peculiarity distinguishes the sea-urchin from all other Testacea, as has already been mentioned.[2]

The structure of the Testacea and of the Crustacea is exactly the reverse of that of the Cephalopoda. For in the latter the fleshy substance is on the outside and the earthy substance within, whereas in the former the soft parts are inside and the hard part without. In the sea-urchin, however, there is no fleshy part whatsoever.

All the Testacea then, those that have not been mentioned

[1] That all Turbinata have opercula is of course an error. In many genera, especially those with large apertures, it is quite rudimentary or obsolete (Woodward, *R. and F. Shells*, p. 102). So also a considerable division of air-breathing gasteropods is inoperculate.

That the operculum corresponds to the second valve of bivalves is a view that has been held by some modern zoologists, erroneously. It represents their *byssus* (Woodward, *R. and F. Shells*, p. 47). Moreover, the bivalve shell is really a single shell, hardened by deposits of lime on the right and left, but with a central strip left uncalcified and soft, so as to allow the two sides to fold together.

[2] I can find no passage to which this can refer.

as well as those that have, agree as stated in possessing a mouth with the tongue-like body, a stomach, and a vent for excrement, but they differ from each other in the positions and proportions of these parts. The details, however, of these differences must be looked for in the Researches con- 680ᵃ
cerning Animals and the treatises on Anatomy.[1] For while there are some points which can be made clear by verbal description, there are others which are more suited for ocular demonstration.[2]

Peculiar among the Testacea are the sea-urchins and the animals known as Tethya (*Ascidians*). The sea-urchins have five teeth,[3] and in the centre of these the fleshy body which is common to all the animals we have been discussing. Immediately after this comes a gullet, and then the stomach, divided into a number of separate compartments, which look like so many distinct stomachs ; for the cavities are separate and all contain abundant residual matter. They are all, however, connected with one and the same oesophagus, and they all end in one and the same excremental vent.[4] There is nothing besides the stomach of a fleshy character, as has already been stated.[5] All that can be seen are the so-

[1] Cf. *H. A.* iv. 4. 528ᵇ 10 sq.

[2] This passage with others shows that the *Hist. Animalium* and the lost treatises on Anatomy were illustrated. Cuvier indeed (*Hist. d. Sc.* i. 141) says the latter contained *coloured* illustrations. I can find no authority for this statement. There is none in the twenty-eight passages referring to the ἀνατομαί collected by Heitz (*Verlor. Schr. des Arist.* p. 70).

[3] Forming what is still known as the 'lantern of Aristotle' from a comparison in the *Hist. An.* (iv. 5. 531ᵃ 5). The central fleshy piece is there said (iv. 5. 530ᵇ 25) to be 'in place of a tongue'. As the sea-urchin has no tongue, the pharyngeal portion of the oesophagus must be meant.

[4] The oesophagus of Echinus terminates in a much wider tube, which is continued to the anus without any distinct separation into stomach and intestine. This gastro-intestinal tube is attached, by what may be called a mesentery, to the inner surface of the shell, in such a manner as to form loops or festoons, five in each of its two coils ; and it is to this appearance of subdivision that A. alludes. This is plain not only from the careful way in which he here guards himself from saying that there are actually a number of distinct stomachs, but still more from his language in *Hist. An.* (iv. 5. 530ᵇ 27), where he says that all the *loops* (κόλποι) of the stomach run together to the anus ; and where also he makes no mention of an intestine as distinct from the stomach.

[5] What he said (679ᵇ 34) was that there was no fleshy part *at all*. Perhaps, therefore, for παρά should be read περί (with U).

called ova,[1] of which there are several, contained each in a separate membrane, and certain black bodies which have no name, and which, beginning at the animal's mouth, are scattered round its body here and there promiscuously.[2] These sea-urchins are not all of one species, but there are several different kinds, and in all of them the parts mentioned are to be found. It is not, however, in every kind that the so-called ova are edible. Neither do these attain to any size in any other species than that with which we are all familiar.[3] A similar distinction may be made generally in the case of all Testacea. For there is a great difference in the edible qualities of the flesh of different kinds; and in some, moreover, the residual substance known as the *mecon*[4] is good for food, while in others it is uneatable. This *mecon* in the turbinated genera is lodged in the spiral part of the shell, while in univalves, such as limpets, it occupies the fundus, and in bivalves is placed near the hinge, the so-called ovum lying on the right;[5] while on the opposite

[1] The 'so-called ova' which A. thought to be masses of fat, or of something analogous to the fat of sanguineous animals, are the ovaries, or in males the testes. These are five in number, and arranged symmetrically round the upper interior of the shell, and would be called by fishermen 'sea-urchins' eggs'.

[2] These mysterious black bodies are also mentioned in the *Hist. An.* (iv. 5. 530^b 31) and are said to be bitter and uneatable. They are further said, in one kind at any rate (530^b 14), to start from the mouth and run in distinct lines that converge towards the aboral aperture of the test, dividing this into segments. This plainly suggests the rows of ambulacral vesicles; and, though these do not appear to be black in any known species, there is generally a certain amount of pigment connected with them in *E. esculentus*, as I am informed by the Director of the Plymouth Laboratory, and this, though scanty in young Echini, becomes more extensive in some of the older specimens. See also Macbride (*Camb. Nat. Hist. Echinod.* pp. 527–8), as to 'masses of pigment' formed in these animals by certain degenerative processes. Admitting, however, these pigmentary deposits to be the 'black bodies' there still remains unexplained the further statement (*H.A.* iv. 5. 530^b 33) that analogous bodies, though of different colour, are present in Frogs, Toads, Tortoises, turbinated Testacea, and Cephalopods.

[3] Frantzius, as also Meyer (*Thierkunde*, p. 175), takes ἐπιπολάζοντα to mean 'floating on this surface'. But no sea-urchins do this, and Frantzius therefore supposes A. to be speaking of dead specimens! Possibly the word may mean 'living *near* the surface', that is in shallow water, in opposition to the deep-sea species (*G.A.* v. 3. 783^a 21 sq.). The most probable interpretation, however, is that given above, meaning the common edible kind.

[4] See 679^b 11 n.

[5] So also *H.A.* iv. 4. 529^b 12. What A. exactly meant by the right

side is the vent. The former is incorrectly termed ovum, for it merely corresponds to what in well-fed sanguineous animals is fat; and thus it is that it makes its appearance in Testacea at those seasons of the year when they are in good condition, namely, spring and autumn. For no Testacea can abide extremes of temperature, and they are therefore in evil plight in seasons of great cold or heat. This is clearly shown by what occurs in the case of the sea-urchins. For though the ova are to be found in these animals even directly they are born, yet they acquire a greater size than usual at the time of full moon; not, as some think, because sea-urchins eat more at that season, but because the nights are then warmer, owing to the moonlight.[1] For these creatures are bloodless, and so are unable to stand cold and require warmth. Therefore it is that they are found in better condition in summer than at any other season; and this all over the world excepting in the Pyrrhean tidal 680b
strait. There the sea-urchins flourish as well in winter as in summer. But the reason for this is that they have a greater abundance of food in the winter, because the fish desert the strait at that season.

The number of the ova is the same in all sea-urchins, and is an odd one. For there are five ova, just as there are also five teeth and five stomachs; and the explanation of this is to be found in the fact that the so-called ova are not really ova, but merely, as was said before, the result of the animal's well-fed condition. Oysters also have a so-called ovum, corresponding in character to that of the sea-urchins, but existing only on one side of their body. Now inasmuch as

and left side of a bivalve it is impossible to say. For he had not made out the position of the mouth, and therefore had no guide as to what was the front aspect. As is not surprising, he entirely failed to make out the internal structure of these animals.

[1] Cicero (*De Divin.* ii. 14) mentions, among other instances of some natural connexion existing between things apparently remote and incongruous, 'that oysters and other shell-fish increase and decrease with the growth and waning of the moon.' So also Lucilius says, 'Luna alit ostrea et implet echinos'; and again Manilius, 'Si submersa fretis, concharum et carcere clausa, Ad lunae motum variant animalia corpus.' The two last quotations I borrow from Mead (*Influence of Sun and Moon*, &c., 1748, p. 65), who accepts the statement as true; as also at the present day, as I am informed, do fishermen on the Riviera.

the sea-urchin is of a spherical form, and not merely a single disk like the oyster, and in virtue of its spherical shape is the same from whatever side it be examined, its ovum must necessarily be of a corresponding symmetry. For the spherical shape has not the asymmetry of the disk-shaped body of the oysters. For in all these animals the head is central, but in the sea-urchin the so-called ovum is above [and symmetrical, while in the oyster it is only on one side].[1] Now the necessary symmetry would be observed were the ovum to form a continuous ring. But this may not be. For it would be in opposition to what prevails in the whole tribe of Testacea; for in all the ovum is discontinuous, and in all excepting the sea-urchins asymmetrical, being placed only on one side of the body. Owing then to this necessary discontinuity of the ovum, which belongs to the sea-urchin as a member of the class, and owing to the spherical shape of its body, which is its individual peculiarity, this animal cannot possibly have an even number of ova. For were they an even number, they would have to be arranged exactly opposite to each other, in pairs, so as to keep the necessary symmetry; one ovum of each pair being placed at one end, the other ovum at the other end of a transverse diameter. This again would violate the universal provision in Testacea. For both in the oysters and in the scallops we find the ovum only on one side of the circumference. The number then of the ova must be uneven, three for instance, or five. But if there were only three they would be much too far apart;[2] while, if there were more than five, they would come to form a continuous mass. The former arrangement would be disadvantageous to the animal, the latter an impossibility. There can therefore be neither more nor less than five. For the same reason the stomach is divided into five parts, and there is a corresponding number of teeth. For seeing that the ova represent each of them a kind of body for the animal, their disposition

[1] An attempt is made in the translation to give some kind of meaning to this unintelligible passage by supposing that *τοῖς δ' ἄλλοις ἐπὶ θάτερα μόνον* should be read here, having been omitted by the copyist because of the occurrence of similar words at the end of the next sentence.

[2] Read *λίαν ἂν ἦν*.

must conform to that of the stomach,[1] seeing that it is from this that they derive the material for their growth. Now if there were only one stomach, either the ova would be too far off from it, or it would be so big as to fill up the whole cavity, and the sea-urchin would have great difficulty in moving about and finding due nourishment for its repletion. As then there are five intervals between the five ova, so are there of necessity five divisions of the stomach, one for each interval. So also, and on like grounds, there are five teeth. For nature is thus enabled to allot to each stomachal com- 681a
partment and ovum its separate and similar tooth. These, then, are the reasons why the number of ova in the sea-urchin is an odd one, and why that odd number is five. In some sea-urchins the ova are excessively small, in others of considerable size, the explanation being that the latter are of a warmer constitution, and so are able to concoct their food more thoroughly; while in the former concoction is less perfect, so that the stomach is found full of residual matter,[2] while the ova are small and uneatable. Those of a warmer constitution are, moreover, in virtue of their warmth more given to motion, so that they make expeditions in search of food, instead of remaining stationary like the rest. As evidence of this, it will be found that they always have something or other sticking to their spines, as though they moved much about; for they use their spines as feet.[3]

The Ascidians differ but slightly from plants, and yet have more of an animal nature than the sponges, which are virtually plants and nothing more. For nature passes from lifeless objects to animals in such unbroken sequence, interposing between them beings which live and yet are not animals, that scarcely any difference seems to exist between two neighbouring groups owing to their close proximity.[4]

[1] For *ζωῆς* read *κοιλίας*.

[2] Literally 'for which reason the uneatable varieties are more full of residual matter', but expanded above for clearness. *Περίττωμα* is here used not for excremental matter but for unconcocted food.

[3] The spines are really instruments of locomotion, and, Agassiz said, were the only ones; but their main function is probably protective, the chief organs of locomotion being the tube-feet, which A. had not noticed in either Echini or Star-fishes.

[4] *H.A.* viii. 588b 4 sq.

A sponge, then, as already said, in these respects completely resembles a plant, that throughout its life it is attached to a rock, and that when separated from this it dies. Slightly different from the sponges are the so-called Holothurias and the sea-lungs, as also sundry other sea-animals that resemble them. For these are free and unattached. Yet they have no feeling, and their life is simply that of a plant separated from the ground. For even among land-plants there are some that are independent of the soil, and that spring up and grow, either upon other plants, or even entirely free. Such, for example, is the plant which is found on Parnassus, and which some call the Epipetrum.[1] This you may hang up on a peg[2] and it will yet live for a considerable time. Sometimes it is a matter of doubt whether a given organism should be classed with plants or with animals. The Ascidians, for instance, and the like so far resemble plants as that they never live free and unattached,[3] but, on the other hand, inasmuch as they have a certain flesh-like substance, they must be supposed to possess some degree of sensibility.

An Ascidian has a body divided by a single septum and with two orifices, one where it takes in the fluid matter that ministers to its nutrition, the other where it discharges the surplus of unused juice, for it has no visible residual substance, such as have the other Testacea. This is itself a very strong justification for considering an Ascidian, and anything else there may be among animals that resembles it, to be of a vegetable character; for plants also never have any residuum.[4] Across the middle of the body of these Ascidians there runs a thin transverse partition, and here it is that we may reasonably suppose the part on which life depends to be situated.

[1] Probably a Sedum. There is an English species, *S. telephium*, which has gained the popular name 'Livelong' from its persistent vitality after being pulled up from the ground.

[2] Literally 'the pegs'; apparently referring to some constant household fixture. Or perhaps 'the rafters'.

[3] Aristotle's Tethya, or Ascidians, are not Tunicata generally, but only the simple solitary Ascidians, which are always sessile.

[4] Cf. ii. 3. 650a 23 note.

The Acalephae,[1] or Sea-nettles, as they are variously called, are not Testacea at all, but lie outside the recognized 681b
groups. Their constitution, like that of the Ascidians, approximates them on one side to plants, on the other to animals. For seeing that some of them can detach themselves and can fasten upon their food, and that they are sensible of objects which come in contact with them, they must be considered to have an animal nature. The like conclusion follows from their using the asperity of their bodies[2] as a protection against their enemies. But, on the other hand, they are closely allied to plants, firstly by the imperfection of their structure, secondly by their being able to attach themselves to the rocks, which they do with great rapidity, and lastly by their having no visible residuum notwithstanding that they possess a mouth.

Very similar again to the Acalephae are the Starfishes. For these also fasten on their prey, and suck out its juices, and thus destroy a vast number of oysters. At the same time they present a certain resemblance to such of the animals we have described as the Cephalopoda and Crustacea, inasmuch as they are free and unattached. The same may also be said of the Testacea.

Such, then, is the structure of the parts that minister to nutrition and which every animal must necessarily possess. But besides these organs it is quite plain that in every animal there must be some part or other which shall be analogous to what in sanguineous animals is the presiding seat of sensation. Whether an animal has or has not blood, it cannot possibly be without this. In the Cephalopoda this part consists of a fluid substance contained in a membrane,

[1] *H. A.* iv. 6. 531a 32 sq. The anemones of our coasts, though richly furnished with nematocysts, very exceptionally cause irritation, when handled, to the fingers. Presumably such irritation must be more common with the Greek anemones, as otherwise they would scarcely have got the general name of Sea-nettles. In all the instances of such stinging by British anemones cited by Gosse (*Br. Sea An.*, pp. 166, xxxviii) the culprit was *Anthea cereus*. This is common in the Mediterranean, and 'would probably be one of the first species of the whole race to become popularly known' (*op. cit.*, p. 162). It was known to Rondelet as *Urtica cinerea*.

[2] More definitely called stinging (*H. A.* ix. 37. 621a 11) and ascribed to the general surface of the body.

through which runs the gullet on its way to the stomach. It is attached to the body rather towards its dorsal surface, and by some is called the *mytis*.[1] Just such another organ is found also in the Crustacea and there too is known by the same name. This part is at once fluid and corporeal and, as before said, is traversed by the gullet. For had the gullet been placed between the *mytis* and the dorsal surface of the animal, the hardness of the back would have interfered with its due dilatation in the act of deglutition. On the outer surface of the *mytis* runs the intestine; and in contact with this latter is placed the ink-bag, so that it may be removed as far as possible from the mouth and its obnoxious fluid be kept at a distance from the nobler and sovereign part. The position of the *mytis* shows that it corresponds to the heart of sanguineous animals; for it occupies the self-same place. The same is shown by the sweetness of its fluid, which has the character of concocted matter and resembles blood.

In the Testacea the presiding seat of sensation is in a corresponding position, but is less easily made out.[2] It should, however, always be looked for in some midway position; namely, in such Testacea as are stationary, midway between the part by which food is taken in and the channel through which either the excrement or the spermatic fluid [3] is voided, and, in those species which are capable
682a of locomotion, invariably midway [4] between the right and left sides.

In Insects this organ, which is the seat of sensation, lies, as was stated in the first treatise,[5] between the head and the cavity which contains the stomach. In most of them it consists of a single part; but in others, for instance in such as have long bodies and resemble the Juli (*Millipedes*), it is

[1] The *mytis*, which in cephalopods is traversed by the oesophagus, is the liver, not the heart (cf. 679a 9 n.). The real heart of cephalopods, as of all other invertebrates, escaped Aristotle.

[2] A. does not profess to have seen the heart of a mollusc, but only to say where it is likely to be found on *a priori* grounds.

[3] 'or the spermatic fluid' is probably an interpolation. For A. (*G. A.* iii. 11. 761b 25) denied the existence of any distinct generative secretion in bivalves.

[4] Read ἐν τῷ μέσῳ (P).

[5] *H. A.* iv. 7. 531b 34.

made up of several parts, so that such insects continue to live after they have been cut in pieces. For the aim of nature is to give to each animal only one such dominant part; and when she is unable to carry out this intention she causes the parts, though potentially many, to work together actually as one. This is much more clearly marked in some insects than in others.

The parts concerned in nutrition are not alike in all insects, but show considerable diversity. Thus some have what is called a sting in the mouth, which is a kind of compound instrument that combines in itself the character of a tongue and of lips. In others that have no such instrument in front there is a part inside the mouth that answers the same sensory purposes. Immediately after the mouth comes the intestine, which is never wanting in any insect. This runs in a straight line[1] and without further complication to the vent; occasionally, however, it has a spiral coil. There are, moreover, some insects in which a stomach succeeds to the mouth, and is itself succeeded by a convoluted intestine, so that the larger and more voracious insects may be enabled to take in a more abundant supply of food. More curious than any are the Cicadae. For here the mouth and the tongue are united so as to form a single part, through which, as through a root, the insect sucks up the fluids on which it lives.[2] Insects are always small eaters, not so much because of their diminutive size as because of their cold temperament. For it is heat which requires sustenance; just as it is heat which speedily concocts it. But cold requires no sustenance. In no insects is this so conspicuous as in these Cicadae. For they find enough to live on in the moisture which is depo-

[1] In most Myriapoda, included by A. among insects, the alimentary canal is a simple tube running in a straight line from mouth to anus. But in some, e. g. Glomeris, the tube, though still simple, is convoluted. In true insects the canal varies much in complexity; but in many is a long convoluted organ divided into a varying number of distinct compartments.

[2] Alluding to the so-called 'rostrum' of Hemipterous insects. This is a suctorial tube formed by the upper and lower lips, within which are the mandibles and maxillae converted into lancet-shaped needles.

sited from the air. So also do the Ephemera[1] that are found about the Black sea. But while these latter only live for a single day, the Cicadae subsist on such food for several days, though still not many.

We have now done with the internal parts of animals, and must therefore return to the consideration of the external parts which have not yet been described. It will be better to change our order of exposition and begin with the animals we have just been describing, so that proceeding from these, which require less discussion, our account may have more time to spend on the perfect kinds of animals, those namely that have blood.

We will begin with Insects. These animals, though they 6
present no great multiplicity of parts, are not without diversities when compared with each other. They are all many-footed; the object of this being to compensate their
682b natural slowness and frigidity, and give greater activity to their motions. Accordingly we find that those which, as the Juli (*Millipedes*), have long bodies, and are therefore the most liable to refrigeration, have also the greatest number of feet. Again, the body in these animals is insected[2]—the reason for this being that they have not got one vital centre but many—and the number of their feet corresponds to that of the insections[3].

Should the feet fall short of this, their deficiency is compensated by the power of flight. Of such flying insects some live a wandering life, and are forced to make long expeditions in search of food. These have a body of light weight, and four feathers, two on either side, to support it. Such are bees and the insects akin to them. When, however, such insects are of very small bulk, their feathers are

[1] The Ephemera of A. are presumably the insects still so named. They are said, however (*H. A.* i. 5. 490a 34), to have only four legs, which is neither true of Ephemera nor of any other insects.

[2] That is, are divided into segments. The ἐντομαί or insections are the more or less complete belts of softer and more pliable integument that form joints between the successive segments, being visible on the upper or under surface of the body or on both; and it is to these ἐντομαί or insections that ἔντομα or insects owe their name (*H. A.* i. 1. 487a 33; iv. 1. 523b 13).

[3] Read κατὰ ταύτας.

reduced to two, as is the case with flies. Insects with heavy [1] bodies and of stationary habits, though not polypterous in the same way as bees, yet have sheaths to their feathers to maintain their efficiency.[2] Such are the Melolonthae [3] and the like. For their stationary habits expose their feathers to much greater risks than are run by those of insects that are more constantly in flight, and on this account they are provided with this protecting shield. The feather of an insect has neither barbs nor shaft.[4] For, though it is called a feather, it is no feather at all, but merely a skin-like membrane that, owing to its dryness, necessarily[5] becomes detached from the surface of the body, as the fleshy substance grows cold.

These animals then have their bodies insected, not only for the reasons already assigned,[6] but also to enable them to curl round in such a manner as may protect them from injury [7]; for such insects as have long bodies [8] can roll themselves up, which would be impossible were it not for the

[1] For *βραχέα* read *βαρέα*, and in the next line for *ἔχει δέ* read *ἔχει γάρ*.

[2] If the Greek text as it stands is correct, we must suppose that A. thought that beetles have elytra—that is shards, *in addition to* their multiple *πτερά*. But it is scarcely credible that A. should have thought this to be the case. I have therefore adopted a suggestion made by Prof. Platt, and read *οὐκ* after *μελίσσαις*. This alteration not only makes the passage intelligible, but, moreover, gives its proper significance to *ὁμοίως*.

[3] Probably Cockchafers. But, if so, the statement as to their development (*H. A.* v. 19. 552^a 16) is quite erroneous.

[4] Frantzius, as also Aubert and Wimmer, renders *πτερόν* when applied to insects as 'wing'. But this part of an insect is never termed *πτέρυξ* by A., but always *πτερόν* or *πτίλον*; and, moreover, is said to contrast with other *πτερά* in being *ἄσχιστον* and *ἄκαυλον*, which can only mean 'without barbs or shaft'. It must, however, be admitted that A. calls bats *δερμόπτερα*, in which title *πτερόν* can only mean 'wing'.

[5] Cf. iv. 5. 677^b 23; 678^a 3 note; *G. A.* ii. 4. 739^b 27.

[6] Or rather 'reason', for only one *αἰτία* was assigned.

[7] Liddell and Scott (7th ed.) interpret *δι' ἀπάθειαν* as 'without suffering pain', which makes admirable sense but seems scarcely tenable. If the reading be correct, the words must apparently be taken as equivalent to *πρὸς τὸ ἀπαθῆ εἶναι* (iii. 11. 673^b 5), *διά* being used in the sense, exceptional in A., of 'for the sake of' as in *διὰ τὴν ἰσχύν* (iv. 10. 687^b 17). Conjecturally, however, the reading may be *δι' ἀκινησίαν*, 'curl round and derive security from remaining motionless'.

[8] The Juli when alarmed coil themselves up in a spiral form, with the feet entirely concealed. The Glomeridæ roll themselves into a perfect ball. Not only long-bodied insects, but some others, roll themselves up. For instance, the ant known as *Myrm. Latreillii* is said by Sir J. Lubbock to do so.

insections; and those that cannot do this can yet draw their segments up into the insected spaces, and so increase the hardness of their bodies. This can be felt quite plainly by putting the finger on one of the insects, for instance, known as Canthari.[1] The touch frightens the insect, and it remains motionless, while its body becomes hard. The division of the body into segments is also a necessary result of there being several supreme organs in place of one; and this again is a part of the essential constitution of insects, and is a character which approximates them to plants. For as plants, though cut into pieces, can still live, so also can insects. There is, however, this difference between the two cases, that the portions of the divided insect live only for a limited time, whereas the portions of the plant live on and attain the perfect form of the whole, so that from one single plant you may obtain two or more.

Some insects are also provided with another means of protection against their enemies, namely a sting. In some this is in front, connected with the tongue, in others behind at the posterior end. For just as the organ of smell in elephants answers several uses, serving alike as a weapon
683a and for purposes of nutrition, so does also the sting, when placed in connexion with the tongue, as in some insects, answer more than one end. For it is the instrument through which they derive their sensations of food, as well as that with which they suck it up and bring it to the mouth. Such of these insects as have no anterior sting are provided with teeth, which serve in some of them for biting the food, and in others for its prehension and conveyance to the mouth. Such are their uses, for instance, in ants and all the

[1] The description of the Canthari in the *Hist. An.* (v. 19. 552a 17), where they are said to roll dung into balls, in which they deposit their progeny, seems to identify them with the Scarabaei of Egypt (*Ateuchus sacer*). Many beetles when touched assume attitudes more or less such as here described. 'The common dung-chaffer, when touched or in fear, sets out its legs as stiff as if they were made of iron wire; which is their posture when dead; and, remaining perfectly motionless, thus deceives,' &c., &c. The pill-beetles 'pack their legs so close to the body, and lie so entirely without motion when alarmed, that they look like a dead body'. Still nearer to A.'s description is the action of certain caterpillars. 'The body is kept stiff and immovable with the separation of the segments scarcely visible' (Kirby and Spence).

various kinds of bees.[1] As for the insects that have a sting behind, this weapon is given them because they are of a fierce disposition. In some of them the sting is lodged inside the body, in bees, for example, and wasps. For these insects are made for flight, and were their sting external and of delicate make it would soon get spoiled ;[2] and if, on the other hand, it were of thicker build,[3] as in scorpions, its weight would be an incumbrance. As for scorpions that live on the ground and have a tail, their sting must be set upon this, as otherwise it would be of no use as a weapon. Dipterous insects never have a posterior sting. For the very reason of their being dipterous is that they are small and weak, and therefore require no more than two feathers to support their light weight ; and the same reason which reduces their feathers to two causes their sting to be in front ; for their strength is not sufficient to allow them to strike efficiently with the hinder[4] part of their body. Polypterous insects, on the other hand, are of greater bulk—indeed it is this which causes them to have so many feathers ; and their greater size makes them stronger in their hinder parts. The sting of such insects is therefore placed behind. Now it is better, when possible, that one and the same instrument shall not be made to serve several dissimilar uses ; but that there shall be one organ to serve as a weapon, which can then be very sharp, and a distinct one to serve as a tongue, which can then be of spongy texture and fit to absorb nutriment. Whenever, therefore, nature is able to provide two separate instruments for two separate uses, without the one hampering the other, she does so,[5] instead

[1] Ants, bees, and Hymenoptera of all kinds have biting jaws or mandibles. It is these that A. calls their 'modified' teeth (iv. 5. 678b 18 note). These mandibles, however, are not used merely or principally for the prehension of food, as stated in the text, but 'comme instruments de sculpture dans les travaux architecturaux de ces animaux' (M. Edwards, *Leçons*, v. 520).

[2] Read *εὔφθαρτα ἂν ἦν.*

[3] For *ἀπεῖχεν* read *παχέα ἦν* (Platt) ; and two lines down for *κέντρον* read *κέρκον*, and for *ἐπὶ ταῦτα* read *ἐπὶ ταύτῃ.*

[4] For *τοῖς ἔμπροσθεν* read *τοῖς ὄπισθεν.*

[5] Here we have a distinct statement of the advantage of division of labour in the animal body ; a truth which Milne Edwards thought he was the first to enunciate. 'Dans les créations de la Nature, de même que dans l'industrie des hommes, c'est surtout par la division du

of acting like a coppersmith who for cheapness makes a spit and lampholder in one.[1] It is only when this is impossible that she uses one organ for several functions.

The anterior legs are in some cases longer[2] than the others, that they may serve to wipe away any foreign matter that may lodge on the insect's eyes and obstruct its sight, which already is not very distinct owing to the eyes being made of a hard substance. Flies and bees and the like may be constantly seen thus dressing themselves with crossed forelegs. Of the other legs, the hinder are bigger than the middle pair, both to aid in running and also that the insect, when it takes flight, may spring more easily from the ground. This difference is still more marked in such insects as leap, in locusts for instance, and in the various kinds of fleas.[3]

travail, que ce perfectionnement s'obtient,' and in a note he adds, 'Ce principe de physiologie générale qui aujourd'hui est adopté par presque tous les zoologistes a été formulé pour la première fois dans un article que j'ai publié en 1827' (M. Edwards, *Leçons*, i. 16).

[1] This strange implement with a double purpose is also mentioned in the *Politics* (iv. 15. 1299b 10); where A. likens it to a board of magistrates charged with a multitude of distinct functions. Among the Graeco-Roman antiquities in the British Museum is a lampholder, to which my attention was directed by Mr. Arthur Smith, and which I think may very probably be an actual ὀβελισκολύχνιον. This holder is a bronze rod, some sixteen inches long, formed at one end into a horse-shoe, within which a small detachable oil-lamp swings freely, so as to have its face uppermost in all positions of the holder. A little way from the other end is a hook, obviously for suspension; while the end itself—and this is the distinctive character—is a spike, intended, as I conjecture, to allow the holder to be stuck in the ground when the lamp was used out of doors or in a tent, as by soldiers, for whose use it was meant (Theopomp. Εἰρήνη, quoted by Pollux, x. 118). When the soldier wanted the holder for cooking purposes, he would detach it from the lamp and fix the meat on the spike as on a toasting-fork, possibly, if the piece was large, further securing it by aid of the hook. In the passage of Theopompus cited above the ὀβελισκολύχνιον is coupled with ξιφομάχαιρα, sword and knife in one. So sergeants in our own army used to carry sword-bayonets, which served both purposes indicated by the name.

[2] The anterior pair of legs are remarkably long in some insects; (Kirby, *Bridg. Tr.* ii. 180); with what use it is difficult to say. Sometimes, at any rate, it seems to be a provision to enable the male to secure the female, the peculiarity being confined to, or most marked in, the former sex. The explanation given by A. can hardly be the correct one; for the anterior pair are not specially elongated in ants or bees, though these are insects that use their legs to dress themselves.

[3] In such insects as are slow walkers all the legs are, as a rule, of much the same length; in those that run quickly all the legs are elongated, the hinder pair being the largest; in swimming insects, and still more in leapers, the hind legs are much longer than the rest. In

For these first bend and then extend the legs, and, by doing so, are necessarily shot up from the ground. It is only the hind legs of locusts, and not the front ones, that resemble the steering oars[1] of a ship. For this requires that the joint 683b
shall be deflected inwards, and such is never the case with the anterior limbs. The whole number of legs, including those used in leaping, is six in all these insects.

7 In the Testacea the body consists of but few parts, the reason being that these animals live a stationary life. For such animals as move much about must of necessity have more numerous parts than such as remain quiet; for their activities are many,[2] and the more diversified the movements the greater the number of organs required to effect them. Some species of Testacea are absolutely motionless, and others not quite but nearly so. Nature, however, has provided them with a protection in the hardness of the shell with which she has invested their body. This shell, as already has been said,[3] may have one valve, or two valves, or be turbinate. In the latter case it may be either spiral, as in whelks, or merely globular,[4] as in sea-urchins. When it has two valves, these may be gaping, as in scallops and mussels, where the valves are united together on one side only, so as to open and shut on the other; or they may be united together on both sides, as in the Solens[5] (*razor-fishes*). In all cases alike the Testacea have, like plants, the head downwards.[6] The reason for this is, that they take in their

fleas the difference is not so marked as in grasshoppers; nor do fleas jump, like the latter, exclusively from the hind legs; for, having placed one in a glass tube under a microscope, I have seen it hop with the anterior legs.

[1] The resemblance of these legs to the long lateral rudder-oars of ancient ships includes not only position but function. 'Whoever,' says Kirby, 'has seen any grasshopper take flight or leap from the ground will find that they stretch out their legs, and like certain birds use them as a rudder' (*Bridg. Treat.* ii. 162).

[2] For διὰ τὸ εἶναι read διὰ τὸ πολλὰς εἶναι (Platt).

[3] Cf. iv. 5. 679b 16.

[4] A. reckons Echinus, though globular, with Turbinata (στρομβώδη).

[5] Probably *Solen marginatus*, see Forbes and Hanley (*Brit. Mollusca*, i. 240).

[6] The ordinary position of most living bivalves is not on their side but vertical, with the opening between the valves downwards. This probably led A. to the conclusion that the head, or what answered to it, was downwards, so as to take in food from below.

nourishment from below, just as do plants with their roots. Thus the under parts come in them to be above, and the upper parts to be below. The body is enclosed in a membrane, and through this the animal filters fluid free from salt and absorbs its nutriment. In all there is a head; but none of the parts, excepting this recipient of food, has any distinctive name.

8 All the Crustacea[1] can crawl as well as swim, and accordingly they are provided with numerous feet. There are four main genera, viz. the Carabi, as they are called, the Astaci, the Carides, and the Carcini. In each of these genera, again, there are numerous species, which differ from each other not only as regards shape, but also very considerably as regards size. For, while in some species the individuals are large, in others they are excessively minute. The Carcinoid and Caraboid Crustacea resemble each other in possessing claws. These claws are not for locomotion, but to serve in place of hands for seizing and holding objects; and they are therefore bent in the opposite direction to the feet, being so twisted as to turn their convexity towards the body, while their feet turn towards it their concavity. For in this position the claws are best suited for laying hold of 684a the food and carrying it to the mouth. The distinction between the Carabi and the Carcini (*Crabs*) consists in the former having a tail while the latter have none. For the Carabi swim about and a tail is therefore of use to them, serving for their propulsion like the blade of an oar. But it would be of no use to the Crabs; for these animals live habitually close to the shore, and creep into holes and corners. In such of them as live out at sea, the feet are much less adapted for locomotion than in the rest, because they are little given to moving about but depend for protection on their shell-like covering. The Maiae[2] and the

[1] For a more detailed account of Crustacea see *H. A.* iv. 2. A. divides those known to him into four groups (1) Carcini—our Brachyura or Crabs. (2) Carabi—our Palinuridae or Spiny Lobsters. (3) Astaci—comprising the Smooth Lobsters and the River Crawfish. (4) Carides—among which are included Prawns, Shrimps, Squills, and other small species.

[2] The very large (*H. A.* iv. 2. 525b 4), hard-shelled (*H. A.* viii. 17.

crabs known as Heracleotic are examples of this; the legs in the former being very thin, in the latter very short.

The very minute crabs that are found among the small fry at the bottom of the net have their hindermost feet flattened out into the semblance of fins or oar-blades, so as to help the animal in swimming.[1]

The Carides are distinguished from the Carcinoid species by the presence of a tail; and from the Caraboids by the absence of claws. This is explained by their large number of feet, on which has been expended the material for the growth of claws. Their feet again are numerous to suit their mode of progression, which is mainly by swimming.

Of the parts on the ventral surface, those near the head are in some of these animals formed like gills, for the admission and discharge of water; while the parts lower down differ in the two sexes. For in the female Carabi these are more laminar than in the males,[2] and in the female crabs the flap is furnished with hairier appendages. This gives ampler space for the disposal of the ova, which the females retain in these parts instead of letting them go free, as do fishes and all[3] other oviparous[4] animals. In the Carabi and in the Crabs the right claw is invariably the larger and the stronger.[5] For it is natural to every animal in active

601^{a} 18), thin-legged Maia, with eyes placed close together near the central line (*H. A.* iv. 3. 527^{b} 13), is doubtless the Spiny Spider-crab (*M. squinado*). There are no sufficient data for determining what are meant by the 'Heracleotic crabs'.

[1] In most crabs the four hinder pairs of feet are formed exclusively for running; but in some few they are flattened out so as to serve in swimming. These swimming crabs are all small. Rondelet mentions several species as found in the Mediterranean.

[2] 'In the Podophthalma, the lamelliform ciliated appendages of the abdominal segments include similar marsupial or incubatory recesses for the ova. The female lobster and other Macrura are distinguished from the male by the greater development of these appendages' (Owen, *Lect.* i. 185). Similarly Cuvier (*Règ. An.* iv. 28), speaking of the flap or tail of the Brachyura, says, 'Triangulaire dans les mâles et garnie seulement à sa base de quatre ou deux appendices, elle s'arrondit, s'élargit et devient bombée dans les femelles. Son dessous offre quatre paires de doubles filets velus, destinés à porter les œufs. Plusieurs de ces filets existent dans les mâles, mais dans un état rudimentaire.'

[3] There are exceptions. Thus some spiders, toads, and even at least one fish carry their ova about with them after extrusion.

[4] For τίκτοντα read ᾠοτοκοῦντα.

[5] This is too absolute a statement; and elsewhere (*H. A.* iv. 3.

operations to use the parts on its right side in preference to those on its left; and nature, in distributing the organs, invariably assigns each, either exclusively or in a more perfect condition, to such animals as can use it. So it is with tusks, and teeth, and horns, and spurs, and all such defensive and offensive weapons.

In the Lobsters alone it is a matter of chance which claw is the larger, and this in either sex.[1] Claws they must have, because they belong to a genus in which this is a constant character; but they have them in this indeterminate way, owing to imperfect formation and to their not using them
684b for their natural purpose, but for locomotion.

For a detailed account of the several parts of these animals, of their position and their differences, those parts being also included which distinguish the sexes, reference must be made to the treatises on Anatomy and to the Researches concerning Animals.[2]

We come now to the Cephalopoda.[3] Their internal 9
organs have already been described[4] with those of other animals. Externally there is the trunk of the body, not distinctly defined, and in front of this the head surrounded by feet, which form a circle about the mouth and teeth, and are set between these and the eyes. Now in all other animals the feet, if there are any, are disposed in one of two ways; either before and behind or along the sides, the latter being the plan in such of them, for instance, as are bloodless and have numerous feet. But in the Cephalopoda there is a peculiar arrangement, different from either of these.

527b 6) A. speaking more carefully says that the rule is general but not universal. There are some grounds for his statement. 'In many species (of the higher Crustacea) the chelae on the opposite sides of the body are of unequal size, the right-handed one being, as I am informed by Mr. C. Spence Bate, generally though not invariably the largest. This inequality is often much greater in the male than in the female' (Darwin, *Desc. of Man*, i. 330). There are, however, some small Crustacea in which the right claw appears to be invariably the bigger. Such, for instance, is the case in some, but not all, species of Hermit-crabs.

[1] This is apparently correct, but not so the further statement that lobsters use their claws only for locomotion and not for prehension.

[2] *H. A.* iv. 2, 3; v. 7. 541b 29.

[3] For a fuller account of Cephalopoda see *H. A.* iv. 1. 523b 21 sq.

[4] Cf. iv. 5. 678b 24 – 679a 31.

For their feet are all placed at what may be called the fore end. The reason for this is that the hind part of their body has been drawn up close to the fore part,[1] as is also the case in the turbinated Testacea. For the Testacea, while in some points they resemble the Crustacea, in others resemble the Cephalopoda. Their earthy matter is on the outside, and their fleshy substance within. So far they are like the Crustacea. But the general plan of their body is that of the Cephalopoda; and, though this is true in a certain degree of all the Testacea, it is more especially true of those turbinated species that have a spiral shell.[2] Of this general plan, common to the two,[3] we will speak presently. But let us first consider the case of quadrupeds and of man, where the arrangement is that of a straight line. Let *A* at the upper end[4] of such a line be supposed to represent the mouth, then *B* the gullet, and *C* the stomach, and the intestine to run from this *C* to the excremental vent where *D* is inscribed. Such is the plan in sanguineous animals; and round this straight line as an axis are disposed the head and so-called trunk; the remaining parts, such as the anterior and posterior limbs, having been superadded by nature, merely to minister to these and for locomotion.

In the Crustacea also and in Insects there is a tendency to a similar arrangement of the internal parts in a straight line; the distinction between these groups and the sanguineous animals depending on differences of the external organs

[1] A similar idea concerning the cuttlefish, viz. that it is comparable to a vertebrate animal bent double, with the approximated arms and legs extending forwards, was advanced in a paper read before the Academy of Sciences in 1830. This paper was referred to Geoffroy St.-Hilaire and Latreille; was reported on most favourably, and its position in fact almost entirely adopted by them. This was the starting-point in the famous controversy between G. St.-Hilaire and Cuvier as to unity of type; the controversy which excited Goethe more than the revolution of 1830 (see Lewes, *Goethe*, ii. 436).

[2] Excluding, that is, the Echini, which A. reckons among Turbinata, notwithstanding their more or less globular shell.

[3] What A. means in this passage is perfectly clear, but the transcribers have evidently misunderstood him and the text consequently requires very free handling.

[4] The manifestly corrupt text may be conjecturally amended as follows: *πρῶτον μὲν ἐπὶ ἄκρῳ τῷ ἄνω τῆς εὐθείας κατὰ τὸ Α τὸ στόμα, ἔπειτα κατὰ τὸ Β τὸν στόμαχον, τὸ δὲ Γ τὴν κοιλίαν, ἀπὸ δὲ τούτου τὸ ἔντερον* (Platt).

which minister to locomotion. But the Cephalopoda and the turbinated Testacea have in common an arrangement
685a which stands in contrast with this. For here the two extremities are brought together by a curve, as if one were to bend the straight line marked *E* until *D* came close to *A*. Such, then, is the disposition of the internal parts; and round these, in the Cephalopoda, is placed the sac (in the Poulps alone called a head),[1] and, in the Testacea, the turbinate shell which corresponds to the sac. There is, in fact, only this difference between them, that the investing substance of the Cephalopoda is soft while the shell of the Testacea is hard, nature having surrounded their fleshy part with this hard coating as a protection because of their limited power of locomotion. In both classes, owing to this arrangement of the internal organs, the excrement is voided near the mouth; at a point below this orifice in the Cephalopoda, and in the Turbinata on one side of it.[2]

Such, then, is the explanation of the position of the feet in the Cephalopoda, and of the contrast they present to other animals in this matter. The arrangement, however, in the Sepias and the Calamaries is not precisely the same as in the Poulps, owing to the former having no other mode of progression than by swimming, while the latter not only swim but crawl. For in the former six[3] of the feet are above the teeth and small, the outer one on either side being the biggest; while the remaining two, which make up the total eight, are below the mouth and are the biggest of all, just as the hind limbs in quadrupeds are stronger than the fore limbs. For it is these that have to support the weight,[4]

[1] The head and body in the Poulps are connected by a broad cervical band. This, and the comparatively small size of the body, doubtless caused the entire mass to be looked on as a head by the vulgar.

[2] In Gasteropoda the mouth and anus are near each other, but never in the same median plane.

[3] After ὀδόντων read ἓξ μικρούς (Gaza) and for μεγίστους τούτων read μεγίστους πάντων.

[4] A. is not quite correct in his view of the part taken by the posterior limbs, at least in Mammalia. For though these take the chief part in the propulsion of the body, it is on the fore limbs that devolves the greater share in its support; and it is, says Owen, this difference in function that explains the different conformation of *manus* and *pes*. Cf. Owen, *Nature of Limbs*, p. 26, and *Archet. of the Skeleton*, p. 167.

and to take the main part in locomotion. And the outer two of the upper six are bigger than the pair which intervene between them and the uppermost of all, because they have to assist the lowermost pair in their office. In the Poulps, on the other hand, the four central feet are the biggest.[1] Again, though the number of feet is the same in all the Cephalopoda, namely eight,[2] their length varies in different kinds, being short in the Sepias and the Calamaries, but greater in the Poulps. For in these latter the trunk of the body is of small bulk, while in the former it is of considerable size; and so in the one case nature has used the materials subtracted from the body to give length to the feet, while in the other she has acted in precisely the opposite way, and has given to the growth of the body what she has first taken from the feet.[3] The Poulps, then, owing to the length of their feet, can not only swim but crawl, whereas in the other genera the feet are useless for the latter mode of progression, being small while the bulk of the body is considerable. These short feet would not enable their possessors to cling to the rocks and keep themselves from being torn off by the waves when these run high in times of storm; neither would they serve to lay hold of objects at all remote and bring them in; but, to supply these defects, the animal is furnished with two long proboscises, by which it can moor itself and ride at anchor like a ship in rough weather. These same processes serve also to catch prey at 685b

[1] There does not seem any very certain rule as to the comparative lengths of the different arms in Sepia and Loligo. The general rule, however, is that there is a gradual increase in length from the dorsal to the ventral pair; and the statement in the text that the ventral pair are the biggest, and the third pair the next in size, accords with this. Neither does there seem to be any certain rule in this matter in Poulps. Cuvier (*Règ. An.* iii. 11) says that their arms are all much of the same length. Owen (*Lect. on Comp. Anat.* i. 344) says that in most of them the dorsal pair are the longest, which accords with *H. A.* iv. 1. 524a 4.

[2] A. does not reckon the two long retractile tentacles or 'proboscises' of sepias and calamaries as feet; so that he is correct in saying that all Cephalopoda are octopodous.

[3] Cf. ii. 9. 655a 28 n. 'The development of the eight external arms bears an inverse proportion to that of the body; they are therefore longer in the short round-bodied Octopi, and shortest in the lengthened calamaries and cuttlefishes, in which the two elongated retractile tentacles are superadded by way of compensation' (Owen, *Lect.* i. 344).

a distance and to bring it to the mouth. They are so used by both the Sepias and the Calamaries. In the Poulps the feet are themselves able to perform these offices, and there are consequently no proboscises. Proboscises[1] and twining tentacles,[2] with acetabula set upon them, act in the same way and have the same structure as those plaited instruments[3] which were used by physicians of old to reduce dislocations of the fingers. Like these they are made by the interlacing of their fibres, and[4] they act by pulling upon pieces of flesh and yielding substances. For the plaited fibres encircle an object in a slackened condition, and when they are put on the stretch they grasp and cling tightly to whatever it may be that is in contact with their inner surface. Since, then, the Cephalopoda have no other instruments with which to convey anything to themselves from without, than either twining tentacles,[5] as in some species, or proboscises as in others, they are provided with these to serve as hands for offence and defence and other necessary uses.

[1] As the Greek text stands A. likens the entire cephalopod, and not merely its various tentacles with their suckers, to a πλεγμάτιον and, moreover, entirely leaves out of account the most important of the instruments he is discussing, namely, the προβοσκίδες of sepias and calamaries; for these are not counted by him as πόδες. I venture therefore to suggest that for ὅσοις should be read ὅσαις and προβοσκίσι for πρὸς τοῖς πόσι.

[2] The term πλεκτάναι, though sometimes used to denote the feet of any cephalopod without distinction, is applied more precisely to the long twining tentacles of the poulps, as contrasted with the comparatively short tentacles of the sepias and calamaries. These πλεκτάναι, and especially the dorsal pair (*H. A.* iv. 1. 524a 4), are held by A. to combine with their common office of feet the function of the long retractile tentacles (προβοσκίδες) of the sepias and calamaries, that is, to lay hold of prey at a distance and draw it to the mouth.

[3] These are the 'Saurae' mentioned by Hippocrates (Kühn's ed. iii. 266). The 'Saura' was a short tube of plaited palm-fibres, in size like the finger of a glove but open at both ends. Placing one end round the dislocated finger, the operator introduced his own finger into the other end, and, on pulling, the tube grasped both fingers tightly and enabled the surgeon to reduce the dislocation. A. likens the προβοσκίς to a Saura; Owen (*Cycl. An. and Phys.* i. 529, fig. 215) with equal aptness to obstetrical forceps.

[4] For αἷς ἕλκουσι read καὶ ἕλκουσι.

[5] Though A. uses carelessly the general term ποσί, he plainly means πλεκτάναις. For parts special to some species of cephalopods, not parts common to all, are clearly indicated; and it is the πλεκτάναι of the poulps that serve like the proboscises of sepias and calamaries to bring objects in from without. After ἄλλην read χρείαν καί (Y).

The acetabula are set in double line in all the Cephalopoda excepting in one kind of poulp, where there is but a single row.[1] The length and the slimness which is part of the nature of this kind of poulp explain the exception. For a narrow space cannot possibly admit of more than a single row. This exceptional character, then, belongs to them, not because it is the most advantageous arrangement, but because it is the necessary consequence of their essential specific constitution.

In all these animals there is a fin, encircling the sac. In the Poulps and the Sepias this fin is unbroken and continuous, as is also the case in the larger calamaries known as Teuthi.[2] But in the smaller kind, called Teuthides, the fin is not only broader than in the Sepias and the Poulps, where it is very narrow, but, moreover, does not encircle the entire sac, but only begins in the middle of the side. The use of this fin is to enable the animal to swim, and also to direct its course. It acts, that is, like the rump-feathers in birds, or the tail-fin in fishes. In none is it so small or so indistinct as in the Poulps.[3] For in these the body is of small bulk and can be steered by the feet sufficiently well without other assistance.

The Insects, the Crustacea, the Testacea, and the Cephalopoda, have now been dealt with in turn; and their parts have been described, whether internal or external.

10 We must now go back to the animals that have blood, and consider such of their parts, already enumerated, as were before passed over. We will take the viviparous animals[4] first, and, when we have done with these, will pass on to the oviparous, and treat of them in like manner.

The parts that border on the head, and on what is known as the neck and throat, have already been taken into con-

[1] The poulp with a single row of suckers is some species of Eledone (*H. A.* iv. 1. 525a 16), *E. cirrhosa* according to Owen.

[2] For the distinctive characters of Teuthi and Teuthides see *H. A.* iv. 1. 524a 29. It is sufficient here to consider them as large and small calamaries without attempting precise identification, as to which zoologists differ greatly.

[3] The Octopodidae have in fact no body-fin at all.

[4] i. e. the Mammalia.

sideration.[1] All animals that have blood have a head;
686a whereas in some bloodless animals, such as crabs, the part which represents a head is not clearly defined. As to the neck, it is present in all the Vivipara, but only in some of the Ovipara; for while those that have a lung also have a neck, those that do not inhale the outer air have none.[2]

The head exists mainly for the sake of the brain. For every animal that has blood must of necessity have a brain; and must, moreover, for reasons already given,[3] have it placed in an opposite region to the heart. But the head has also been chosen by nature as the part in which to set some of the senses; because its blood is mixed in such suitable proportions as to ensure their tranquillity and precision, while at the same time it can supply the brain with such warmth as it requires. There is yet a third constituent superadded to the head, namely the part which ministers to the ingestion of food. This has been placed here by nature, because such a situation accords best with the general configuration of the body. For the stomach could not possibly be placed above the heart, seeing that this is the sovereign organ; and if placed below, as in fact it is, then the mouth could not possibly be placed there also. For this would have necessitated a great increase in the length[4] of the body; and the stomach, moreover, would have been removed too far from the source of motion and of concoction.[5]

The head, then, exists for the sake of these three parts; while the neck, again, exists for the sake of the windpipe.

[1] Cf. ii. 10–iii. 3.

[2] i.e. Fishes. Serpents, though they have a lung, have no neck. This exception, though not noted here, is dealt with in the next chapter.

[3] Cf. ii. 7. 652b 17.

[4] Read πολὺ γὰρ ἂν τὸ μῆκος ἦν (P).

[5] The argument is this. 'The stomach cannot be placed above the heart, for such a position would be inconsistent with the dignity of the chief organ (cf. ii. 2. 648a 13 n.); it must therefore be placed below it. But if the mouth were also placed below the heart, the stomach, owing to the length of the oesophagus, would be removed so far from the heart, that digestion, which is due to heat derived from the heart, would not be possible.' A. forgets that elsewhere (iii. 3. 664a 23) he has said that the oesophagus is only necessary, because there is a neck, and that, but for this, the stomach might come immediately after the mouth.

For it acts as a defence to this and to the oesophagus, encircling them and keeping them from injury. In all other animals this neck is flexible and contains several vertebrae; but in wolves and lions it contains only a single bone.[1] For the object of nature was to give these animals an organ which should be serviceable in the way of strength, rather than one that should be useful for any of the other purposes to which necks are subservient.[2]

Continuous with the head and neck is the trunk with the anterior limbs. In man the forelegs and forefeet are replaced by arms and by what we call hands. For of all animals man alone stands erect, in accordance with his god-like nature and essence. For it is the function of the god-like to think and to be wise; and no easy task were this under the burden of a heavy body, pressing down from above and obstructing by its weight the motions of the intellect and of the general sense.[3] When, moreover, the weight and corporeal substance become excessive, the body must of necessity incline towards the ground. In such cases therefore nature, in order to give support to the body, has replaced the arms and hands by forefeet, and has thus converted the animal into a quadruped. For, as every animal that walks must of necessity have the two hinder feet, such 686b
an animal becomes a quadruped, its body inclining downwards in front from the weight which its soul cannot sustain.

[1] Though there were lions in N. Greece in A.'s time they were rare and confined to a small locality (*H. A.* vi. 31. 579^b 6), and A. clearly was scantily informed about them; for nearly all his statements about their structure are erroneous. Here he says that they have only one cervical vertebra; a little later on he says they have but two dugs; elsewhere that their bones are without medullary cavity, &c.

[2] Such uses, for instance, as turning round quickly to guard the hinder part against a foe (iv. 11. 692^a 5); picking up food from the bottom of the water, as do web-footed and other water-birds (iv. 12. 693^a 8); or catching prey at a distance, the long neck serving as a fishing rod (iv. 12. 693^a 23).

[3] There are some perceptions, says A., that are peculiar to one sense, e. g. colour to vision, hardness and temperature to touch, &c. But there are others not peculiar to one sense, but appreciable by several, or at any rate by vision and by touch. Such are motion, rest, number, figure, magnitude. These, then, are common sensibles, and that which perceives them is the one common or general sense, of which the five senses are special forms. Cf. *De An.* iii. 1 and 2; *De Som.* 2; *De Sens.* 4. 442^b 4.

For all animals, man alone excepted, are dwarf-like in form. For the dwarf-like is that in which the upper part is large, while that which bears the weight and is used in progression is small. This upper part is what we call the trunk,[1] which reaches from the mouth to the vent. In man it is duly proportionate to the part below, and diminishes much in its comparative size as the man attains to full growth. But in his infancy the contrary obtains, and the upper parts are large, while the lower part is small; so that the infant can only crawl, and is unable to walk; nay, at first cannot even crawl, but remains without motion. For all children are dwarfs in shape, but cease to be so as they become men, from the growth of their lower part; whereas in quadrupeds the reverse occurs, their lower parts being largest in youth, and advance of years bringing increased growth above, that is in the trunk, which extends from the rump to the head. Thus it is that colts are scarcely, if at all, below full-grown horses in height; and that while still young they can touch their heads with the hind legs, though this is no longer possible when they are older. Such, then, is the form of animals that have either a solid or a cloven hoof. But such as are polydactylous and without horns, though they too are of dwarf-like shape, are so in a less degree; and therefore the greater growth of the lower parts as compared with the upper is also small, being proportionate to this smaller deficiency.[2]

Dwarf-like again is the race of birds and fishes; and so in fact, as already has been said, is every animal that has blood. This is the reason why no other animal is so intelli-

[1] In the Greek text 'thorax' (θώραξ); this term not being as yet restricted to the cavity above the diaphragm, cf. *H. A.* i. 7. 491a 29.

[2] Cf. *H. A.* ii. 1. 500b 26 sq. This statement as to the alteration that occurs in the human body in the relative proportions of the upper and lower parts is correct. 'After birth, the proportions of the body alter in consequence of the legs growing faster than the rest of the body. In consequence, the middle point of the height of the body—which at birth is situated about the umbilicus—becomes gradually lower until, in the adult male, it is as low as the symphysis pubis' (Huxley, *Vert.* p. 488). On the other hand, every one is familiar with the preponderant length of a colt's legs as compared with that of its body. Lastly, if one compares a kitten with a cat, one finds no such contrast of proportions.

gent as man. For even among men themselves if we compare children with adults, or such adults as are of dwarf-like shape with such as are not, we find that, whatever other superiority the former may possess, they are at any rate deficient as compared with the latter in intelligence. The explanation, as already stated, is that their psychical principle is corporeal, and much impeded in its motions. Let now a further decrease occur in the elevating heat, and a further increase in the earthy matter, and the animals become smaller in bulk, and their feet more numerous, until at a later stage they become apodous, and extended full length on the ground. Then, by further small successions of change, they come to have their principal organ below; and at last their cephalic part becomes motionless and destitute of sensation. Thus the animal becomes a plant, that has its upper parts downwards and its lower parts above. For in plants the roots are the equivalents of mouth and head, while the seed has an opposite significance,[1] for it is 687a
produced above at the extremities of the twigs.

The reasons have now been stated why some animals have many feet, some only two, and others none; why, also, some living things are plants and others animals; and, lastly, why man alone of all animals stands erect. Standing thus erect, man has no need of legs in front, and in their stead has been endowed by nature with arms and hands. Now it is the opinion of Anaxagoras that the possession of these hands is the cause of man being of all animals the most intelligent. But it is more rational to suppose that his endowment with hands is the consequence rather than the cause of his superior intelligence. For the hands are instruments or organs, and the invariable plan of nature in distributing the organs is to give each to such animal as can make use of it; nature acting in this matter as any prudent man would do. For it is a better plan to take a person who is already a flute-player and give him a flute, than to take one who possesses a flute and teach him the art of flute-playing. For nature adds that which is less to that which

[1] Answers, that is to say, to the residual nutriment of animals. Cf. ii. 3. 650a 20 n.

is greater and more important, and not that which is more valuable and greater to that which is less. Seeing then that such is the better course, and seeing also that of what is possible nature invariably brings about the best, we must conclude that man does not owe his superior intelligence to his hands, but his hands to his superior intelligence. For the most intelligent of animals is the one who would put the most organs to use; and the hand is not to be looked on as one organ but as many; for it is, as it were, an instrument for further instruments.[1] This instrument, therefore,—the hand—of all instruments the most variously serviceable, has been given by nature to man, the animal of all animals the most capable of acquiring the most varied handicrafts.

Much in error, then, are they who say that the construction of man is not only faulty, but inferior to that of all other animals; seeing that he is, as they point out, barefooted, naked, and without weapon of which to avail himself. For other animals have each but one mode of defence, and this they can never change; so that they must perform all the offices of life and even, so to speak, sleep with sandals on, never laying aside whatever serves as a protection to their bodies, nor changing such single weapon as they may chance to possess. But to man numerous modes of defence
687b are open, and these, moreover, he may change at will; as also he may adopt such weapon as he pleases, and at such times[2] as suit him. For the hand is talon, hoof, and horn, at will. So too it is spear, and sword, and whatsoever other weapon or instrument you please; for all these can it be from its power of grasping and holding them all. In harmony with this varied office is the form which nature has contrived[3] for it. For it is split into several divisions, and these are capable of divergence. Such capacity of divergence does not prevent their again converging so as to form a single compact body, whereas had the hand been an undivided mass, divergence would have been impossible.

[1] Cf. *Polit.* i. 4. 1253b 33.

[2] Read *ὁπόταν* for *ὅπου ἄν*.

[3] For *συμμεμηχανῆσθαι* read *συμμεμηχάνηται* and omit *καί* before *τῇ φύσει*.

The divisions also may be used singly or two together and in various combinations.[1] The joints, moreover, of the fingers are well constructed for prehension and for pressure. One of these also, and this not long like the rest but short and thick, is placed laterally. For were it not so placed all prehension would be as impossible, as were there no hand at all. For the pressure of this digit is applied from below upwards, while the rest act from above downwards; an arrangement which is essential, if the grasp is to be firm and hold like a tight clamp. As for the shortness of this digit, the object is to increase its strength, so that it may be able, though but one, to counterbalance its more numerous[2] opponents. Moreover, were it long it would be of no use. This is the explanation[3] of its being sometimes called the great digit, in spite of its small size; for without it all the rest would be practically useless. The finger which stands at the other end of the row is small, while the central one of all is long, like a centre oar[4] in a ship. This is rightly so; for it is mainly by the central part of the encircling grasp that a tool must be held when put to use.

No less skilfully contrived are the nails. For, while in man these serve simply as coverings to protect the tips of the fingers, in other animals they are also used for active purposes; and their form in each case is suited to their office.

The arms in man and the fore limbs in quadrupeds bend in contrary directions, this difference having reference to the

[1] If the text be correct, by ἑνί must be meant one of the divisions implied in διαιρετή, viz. one of the fingers. Not only is this a very strange construction, but τῶν δακτύλων in the next sentence seems to mark that as the beginning of the account of the fingers. We should also expect πλείοσι rather than πολλαχῶς if fingers are meant. May it not be that for ἑνί should be read μιᾷ, the transcriber having been led to make this mistake by the ἔνι that begins the preceding sentence? 'The hands also may be used singly or together and in various combinations.'

[2] Transposing ἵνα . . . πολλοῖς to follow τὴν ἰσχύν.

[3] Transpose καὶ διά . . . ἄνευ τούτου to come after εἰ μακρός.

[4] For μέσον νέως read μεσόνεως (Schneider). According to Dr. Warre (Badminton, *Boating*, p. 14) the midship oars in an ancient Greek vessel were longer and heavier than those nearer stern and prow; and consequently it was these centre oars that poets put in the hands of heroes, see Apoll. Rhodius, *Argon.* i. 395–400.

ingestion of food and to the other offices which belong to these parts. For quadrupeds must of necessity bend their anterior limbs inwards that they may serve in locomotion, for they use them as feet.[1] Not but what even among quadrupeds there is at any rate a tendency for such as are polydactylous to use their forefeet not only for locomotion
688a but as hands. And they are in fact so used, as any one may see. For these animals seize hold of objects, and also repel assailants with their anterior limbs; whereas quadrupeds with solid hoofs use their hind legs for this latter purpose. For their fore limbs are not analogous to the arms and hands of man.[2]

It is this hand-like office of the anterior limbs which explains why in some of the polydactylous quadrupeds, such as wolves, lions, dogs, and leopards, there are actually five digits on each forefoot, though there are only four on each hind one. For the fifth digit of the foot corresponds to the fifth digit of the hand,[3] and like it is called the big one. It is true that in the smaller polydactylous quadrupeds the hind feet also have each five toes. But this is because these animals are creepers; and the increased number of nails serves to give them a tighter grip, and so enables them to creep up steep places with greater facility,[4] or even to run head downwards.

In man between the arms, and in other animals between the forelegs, lies what is called the breast. This in man is broad, as one might expect; for as the arms are set laterally on the body, they offer no impediment to such expansion in this part. But in quadrupeds the breast is

[1] Reading ὡς (P) before ποσίν, and substituting a comma for the colon after κῶλα.

[2] Analogous is here used in the modern sense, i. e. having similar functions, and not as equivalent to homologous.

[3] And therefore is not wanted, as the hind foot has no hand-like office such as that of the corresponding forefeet.

[4] In Canidae and Felidae, from which A.'s examples are taken, there are only four toes to the hind foot, while the forefeet have each five, as in most Unguiculata. The smaller quadrupeds, that are described as having five hind toes and as creeping or even running head downwards, are such animals as rats, squirrels, moles, martens, weasels. It is, however, not only small quadrupeds and creepers that have five hind toes; for the same is the case with elephants and bears.

narrow, owing to the legs having to be extended in a forward direction in progression and locomotion.

Owing to this narrowness the mammae of quadrupeds are never placed on the breast. But in the human body there is ample space in this part; moreover, the heart and neighbouring organs require protection, and for these reasons this part is fleshy and the mammae are placed upon it separately, side by side, being themselves of a fleshy substance in the male and therefore of use in the way just stated; while in the female, nature, in accordance with what we say is her frequent practice, makes them minister to an additional function, employing them as a store-place of nutriment for the offspring. The human mammae are two in number, in accordance with the division of the body into two halves, a right and a left. They are somewhat firmer than they would otherwise be, because the ribs[1] in this region are joined together; while they form two separate masses, because their presence is in no wise burdensome.[2] In other animals[3] than man, it is impossible for the mammae to be placed on the breast between the forelegs, for they would interfere with locomotion; they are therefore disposed of otherwise, and in a variety of ways.[4] Thus in such animals as produce but few at a birth, whether horned quadrupeds or those with solid hoofs, the mammae are placed in the region of the thighs, and are two in number,[5] while in such as produce litters, or such as are polydactylous, the dugs

[1] The upper or true ribs which are united to the sternum, in opposition to the false ribs below. Thus there is firmness given to the mammae by the firm substratum. For ἀλλήλας read ἀλλήλαις.

[2] As the arms are not used for locomotion, the mammae are not in the way, and so there is no disadvantage in there being two of them; otherwise they would be made to form a single mass.

[3] Elsewhere (*H. A.* ii. 8. 502^{a} 34), apes, as well as man, are excepted. Pectoral mammae are by no means confined, however, to man and apes. In bats, for instance, the two mammae are pectoral; so also in elephants, as indeed is presently mentioned.

[4] Omit ἤδη before πολλούς.

[5] The horned animals which produce few at a birth and have only two mammae are sheep and goats. For in other horned animals, e. g. the cow, there are four, as A. elsewhere (*H. A.* ii. 1. 499^{a} 19) mentions. Even in sheep and goats there are really four; but two of these are usually rudimentary. The Solidungula have, as correctly stated, only two mammae and these inguinal.

are either numerous and placed laterally on the belly, as in swine and dogs, or are only two in number, being set, however, in the centre [1] of the abdomen, as is the case in the lion.[2]
688b The explanation of this latter condition is not that the lion produces few at a birth, for sometimes it has more than two cubs at a time, but is to be found in the fact that this animal has no plentiful supply of milk. For, being a flesh-eater, it gets food at but rare intervals, and such nourishment as it obtains is all expended on the growth of its body.

In the elephant also there are but two mammae, which are placed under the axillae of the fore limbs. The mammae are not more than two, because this animal has only a single young one at a birth; and they are not placed in the region of the thighs, because they never occupy that position in any polydactylous animal such as this. Lastly, they are placed above, close to the axillae, because this is the position of the foremost dugs in all animals whose dugs are numerous, and the dugs so placed give the most milk. Evidence of this is furnished by the sow. For she always presents these foremost dugs to the first-born of her litter. A single young one is of course a first-born, and so such animals as only produce a single young one must have these anterior dugs to present to it; that is they must have the dugs which are under the axillae. This, then, is the reason why the elephant has but two mammae, and why they are so placed. But, in such animals as have litters of young, the dugs are disposed about the belly; the reason being that more dugs are required by those that will have more young to nourish. Now it is impossible that these dugs should be set transversely in rows of more than two, one, that is, for each side of the body, the right and the left [3]; they must therefore be

[1] In opposition to the general rule in bi-mammary animals, whose mammae, as said a few lines back, are set ἐν τοῖς μηροῖς, that is are inguinal, or are pectoral as in man.

[2] The number and position of the mammae are given correctly by A. in the other instances; but as usual he is in error as regards the lion; for though its mammae are, as stated, abdominal, they are four, not two, in number. The lion produces not unfrequently four, and occasionally even five or six, at a birth (*G. A.* iii. 10. 760b 23).

[3] The διά . . . δεξιόν must refer in sense to the preceding δύο, not to the μόνους. There must be two in each row because of the require-

placed lengthways, and the only place where there is sufficient length for this is the region between the front and hind legs. As to the animals that are not polydactylous but produce few at a birth, or have horns, their dugs are placed in the region of the thighs.[1] The horse, the ass, the camel are examples ; all of which bear but a single young one at a time, and of which the two former have solid hoofs, while in the last the hoof is cloven. As still further examples may be mentioned the deer, the ox, the goat, and all other similar animals.

The explanation is that in these animals growth takes place in an upward direction ;[2] so that there must be an abundant collection of residual matter and of blood in the lower region, that is to say in the neighbourhood of the orifices for efflux, and here therefore nature has placed the mammae. For the place in which the nutriment is set in motion must also be the place whence nutriment can be derived by them. In man there are mammae in the male as well as in the female ; but some of the males of other animals are without them. Such, for instance, is the case with horses, some stallions being destitute of these parts, while others that resemble their dams have them.[3] Thus much then concerning the mammae.

Next after the breast comes the region of the belly, which
is left unenclosed by the ribs for a reason which has already 689a
been given ;[4] namely that there may be no impediment to the swelling which necessarily occurs in the food as it gets heated, nor to the expansion of the womb in pregnancy.

ments of bilateral symmetry (cf. 688a 26), and not more than two, because of the narrow space.

[1] Omit καί before ἐν τοῖς μηροῖς.

[2] i. e. in the direction from tail to head. This upward growth implies, he says, the accumulation of nutriment in the part from which the growth proceeds, for otherwise there would be no material for the growth ; and it is in this land of plenty that the mammae are placed. In the human body the growth takes place in the contrary direction, and the seat of plenty and location of the mammae is accordingly at the opposite or pectoral end. As to direction of growth cf. 686b 32 note.

[3] Linnaeus counted the horse among those exceptional quadrupeds in which the male has no teats ; but John Hunter discovered vestiges of them in the stallion. Possibly what A. says may be true, and thus the discrepancy between these two modern authorities explained.

[4] Cf. ii. 9. 655a 2.

At the extreme end of what is called the trunk are the parts concerned in the evacuation of the solid and also of the fluid residue. In all sanguineous animals with some few exceptions,[1] and in all Vivipara without any exception at all, the same part which serves for the evacuation of the fluid residue is also made by nature to serve in sexual congress, and this alike in male[2] and female. For the semen is a kind of fluid and residual matter.[3] The proof of this will be given hereafter,[4] but for the present let it be taken for granted. (The like holds good of the menstrual fluid in women, and of the part where they[5] emit semen. This also, however, is a matter of which a more accurate account will be given hereafter. For the present let it be simply stated as a fact, that the catamenia of the female like the semen of the male are residual matter.[6] Both of them, moreover,

[1] This passage is translated as it stands; but the text cannot but be corrupt. For it makes A. say that all oviparous vertebrates with some few exceptions form urine, in contradiction of his repeated and distinct statement (e.g. iii. 8 and 9, iv. 13. 697a 13; *H. A.* ii. 16) that none of them do so or have either kidneys or bladder, except tortoises. I have no doubt that what A. really said here was as follows: '*In all such sanguineous animals as are viviparous and in some few of those that are oviparous, the same part*,' &c.; the 'some few' being the various tortoises, as to whose coitus see *H. A.* v. 3, v. 5. 541a 8. For ἔξω . . . ἐναίμοις, therefore, I would read ἐν ὀλίγοις τισὶν τῶν ᾠοτόκων.

[2] For τῶν ἀρρένων read τοῖς ἄρρεσιν.

[3] See note 6 and ii. 14. 658a 23 note.

[4] *G. A.* i. 18. 724b 21–726a 25.

[5] If the reading be correct, A. apparently attributes to females the secretion of γονή *in addition to* the καταμήνια. So also in the *H. A.* (i. 3. 489a 9–13) he attributes to them the secretion of σπέρμα. But when he considers the question more fully in the *G. A.* he again and again (e.g. *G. A.* i. 19. 727a 1 and 28) maintains that the καταμήνια are themselves the female equivalent of γονή or σπέρμα. Prof. Platt, however, ingeniously suggests that the reading should be εἰ προΐενταί τινα γονήν, 'and of the semen if so be that they emit any.'

[6] Hippocrates (Kühn ed. i. 551) had said, in partial anticipation of Darwin's doctrine of pangenesis, that the semen was formed by contributions from all parts of the parent's body; and he explained on this hypothesis the resemblance of the offspring to the parent, which extended occasionally even to accidental or acquired peculiarities of structure. This opinion is combated by A. (*G. A.* i. 17, 18), who insists, among other arguments, that it would imply that the semen was a product of dissolution or decay (σύντηξις), which is clearly inadmissible. He argues that the semen can be nothing else in substance than part of that surplus or residue of sound nutriment, which, after conversion into blood, has not been required for the growth or maintenance of the bodily fabric. This, he says, explains why no semen is formed either when the growth is active, as in

being fluid, it is only natural that the parts which serve for voidance of the urine should give issue to residues which resemble it in character.[1]) Of the internal structure of these parts, and of the differences which exist between the parts concerned with semen and the parts concerned with conception, a clear account is given in the book of Researches concerning Animals and in the treatises on Anatomy. Moreover, I shall have to speak of them again when I come to deal with Generation.[2] As regards, however, the external shape of these parts, it is plain enough that they are adapted to their operations, as indeed of necessity they must be. There are, however, differences in the male organ corresponding to differences in the body generally. For all animals are not of an equally sinewy nature. This organ, again, is the only one that, independently of any morbid change, admits of augmentation and of diminution of bulk. The former condition is of service in copulation, while the other is required for the advantage of the body at large. For, were the organ constantly in the former condition, it would be an incumbrance. The organ therefore has been formed of such constituents as will admit of either state. For it is partly sinewy, partly cartilaginous,[3] and thus is enabled either to contract or to become extended, and is capable of admitting air.[4]

childhood, or when the power of concocting nutriment is small, as in old age or sickness; and also why those animals whose surplus nutriment is turned into fat are not prolific (ii. 5. 651b 13). The semen, then, instead of being, as Hippocrates would have it, something which comes from each and every part of the parent, is something which might have gone to each and every part of the parent. To the semen of the male corresponds the menstrual discharge of the female; but, in accordance with the colder nature of females, their generative secretion is less concocted (*G. A.* iv. 5. 774a 2), and therefore retains a greater resemblance to blood.

[1] Omitting τῶν αὐτῶν καί.

[2] *H. A.* i. 13, 14, i. 17. 497a 27, iii. 1; *G. A.* i. 2–16.

[3] Elsewhere (*H. A.* ii. 1. 500b 22) sundry Carnivora are correctly stated to have a bone in the penis; the camel and stag to have no such bone, but a sinewy organ, also correctly; and man to have cartilage in the part, which chances to be true of some negroes. In no other case, however, does the penis contain cartilage. As to the presence of sinew conferring the power of contraction, cf. iii. 4. 666b 14 note.

[4] Erection was attributed to air, not to blood (*Probl.* xxx. 1. 953b 34); as also emission (*H. A.* vii. 7. 586a 16).

All female quadrupeds void their urine backwards, because the position of the parts which this implies is useful to them in the act of copulation. This is the case with only some few males, such as the lynx, the lion, the camel, and the hare.[1] No quadruped with a solid hoof is retromingent.

689b The posterior portion of the body and the parts about the legs are peculiar in man as compared with quadrupeds. Nearly all these latter have a tail, and this whether they are viviparous or oviparous. For, even if the tail be of no great size, yet they have a kind of scut, as at any rate a small representative[2] of it. But man is tail-less. He has, however, buttocks, which exist in none of the quadrupeds. His legs also are fleshy (as too are his thighs and feet);[3] while the legs in all other animals that have any, whether viviparous or not, are fleshless, being made of sinew and bone and spinous substance. For all these differences there is, so to say, one common explanation, and this is that of all animals man alone stands erect. It was to facilitate the maintenance of this position that Nature made his upper parts light, taking away some of their corporeal substance, and using it to increase the weight of the parts below, so that the buttocks, the thighs, and the calves of the legs were all made fleshy. The character which she thus gave to the buttocks renders them at the same time useful in

[1] The camel, the cats, and many rodents including the hare, are retromingent.

[2] For σμικροῦ read σημείου (Bonitz).

[3] For κνήμας read πόδας (Y).

A. uses the term σκέλος, as we use 'leg', to designate not only the entire limb, but also that lower part of it which lies between thigh and foot; but, as he shares the popular misconception which identifies the knee-joint of man with what is really the tarsal joint of other vertebrates, the tibial segment in man with its fleshy calf (κνήμη and γαστροκνημία) and the scraggy metatarsal segment of quadrupeds and birds come to be the σκέλη which he supposes to correspond anatomically and compares with each other.

The same misconception as to the knee-joint causes him to find the counterpart of the human femur in the tibial segment of the other vertebrates; but this leaves him in the case of these vertebrates with an extra limb-segment (the femur) unaccounted for. The human femur is jointed to the pelvic ischium, and therefore A. calls this extra segment an ischium, though it is a separate bone, and looks, he is bound to admit, when detached from its surroundings, just like a femur (*H. A.* ii. 12. 503b 35).

resting the body. For standing causes no fatigue to quadrupeds, and even the long continuance of this posture produces in them no weariness; for they are supported the whole time by four props, which is much as though they were lying down. But to man it is no easy task to remain for any length of time on his feet, his body demanding rest in a sitting position. This, then, is the reason why man has buttocks and fleshy legs; and the presence of these fleshy parts explains why he has no tail. For the nutriment which would otherwise go to the tail is used up in the production of these parts, while at the same time the existence of buttocks does away with the necessity of a tail. But in quadrupeds and other animals the reverse obtains. For they are of dwarf-like form, so that all the pressure of their weight and corporeal substance is on their upper part, and is withdrawn from the parts below.[1] On this account they are without buttocks and have hard legs. In order, however, to cover and protect that part which serves for the evacuation of excrement, nature has given them a tail of some kind or other, subtracting for the purpose some of the nutriment which would otherwise go to the legs. Intermediate in shape between man and quadrupeds is the ape, belonging therefore to neither or to both, and having on this account neither tail nor buttocks; no tail in its character of biped, no buttocks in its character of quadruped. There is a great diversity of so-called tails; and this organ like others 690a
is sometimes used by nature for by-purposes, being made to serve not only as a covering and protection to the fundament, but also for other uses and advantages of its possessor.

There are differences in the feet of quadrupeds. For in some of these animals there is a solid hoof, and in others a hoof cloven into two, and again in others a foot divided into many parts.

The hoof is solid when the body is large and the earthy matter present in great abundance; in which case the earth, instead of forming teeth and horns, is separated in the character of a nail, and being very abundant forms one

[1] i. e. the hind legs, *H. A.* ii. 1. 500b 29.

continuous nail, that is a hoof, in place of several. This consumption of the earthy matter on the hoof explains why these animals, as a rule, have no [1] huckle-bones; a second reason [2] being that the presence of such a bone in the joint of the hind leg somewhat impedes its free motion. For extension and flexion can be made more rapidly in parts that have but one angle than in parts that have several. But the presence of a huckle-bone, as a connecting bolt, is the introduction as it were of a new limb-segment between the two ordinary ones. Such an addition adds to the weight of the foot, but renders the act of progression more secure. Thus it is that in such animals as have a huckle-bone, it is only in the posterior and not in the anterior limbs that this bone is found. For the anterior limbs, moving as they do in advance of the others, require to be light and capable of ready flexion, whereas firmness and extensibility are what are wanted in the hind limbs. Moreover, a huckle-bone adds weight to the blow of a limb, and so renders it a suitable weapon of defence; and these animals all use their hind legs to protect themselves, kicking out with their heels against anything which annoys them. In the cloven-hoofed quadrupeds the lighter character of the hind legs admits of there being a huckle-bone; and the presence of the huckle-bone prevents them from having a solid hoof, the bony substance remaining in the joint, and therefore being deficient in the foot. As to the polydactylous quadrupeds, none of them have huckle-bones. For if they had they would not be polydactylous, but the divisions of the foot would only extend to that amount of its breadth which was covered by the huckle-bone.[3] Thus it is that most [4] of the animals that have huckle-bones are cloven-hoofed.

[1] Not every tarsal bone, which modern anatomists call astragalus, was so called by A., but only such as in size and shape were suitable for the ancient game which has come down to us as the game of huckle-bone or knuckle-bone. Such are the astragali of the smaller ruminants.

[2] Read *καί* before *διὰ τὸ δυσκινητοτέραν* (S U).

[3] A. probably means that, if there were an astragalus, there would be much earthy matter; and, if much earthy matter, then the hoof would be a solid mass; excepting in that part of its breadth where the earthy matter was used up in making the astragalus.

[4] As to the supposed exceptions see *H. A.* ii. 1. 499b 20.

Of all animals man has the largest foot in proportion to the size of the body.[1] This is only what might be expected. For seeing that he is the only animal that stands erect, the two feet which are intended to bear all the weight of the body must be both long and broad. Equally intelligible is it that the proportion between the size of the fingers and that of the whole hand should be inverted in the case of the toes and feet. For the function of the hands is to take hold of objects and retain them by pressure ; so that the fingers require to be long. For it is by its flexed portion that the hand grasps an object. But the function of 690b
the feet is to enable us to stand securely, and for this[2] the undivided part of the foot requires to be of larger size than the toes. However, it is better for the extremity to be divided than to be undivided. For in an undivided foot disease of any one part would extend to the whole organ ; whereas, if the foot be divided[3] into separate digits, there is not an equal liability to such an occurrence. The digits, again, by being short would be less liable to injury. For these reasons the feet in man are many-toed, while the separate digits are of no great length. The toes, finally, are furnished with nails for the same reason as are the fingers, namely because such projecting parts are weak and therefore require special protection.

We have now done with such sanguineous animals as live on land and bring forth their young alive ;[4] and, having dealt with all their main kinds, we may pass on to such
11 sanguineous animals as are oviparous. Of these some have four feet, while others have none. The latter form a single genus, namely the Serpents ; and why these are apodous has been already explained in the dissertation on Animal

[1] 'L'homme a les pieds plus larges, et il peut les écarter l'un de l'autre plus que les autres animaux . . . . La grandeur de la surface du pied de l'homme tient à ce qu'il appuye le tarse, le métatarse et tous les doigts à terre, ce qu'aucun animal ne fait aussi parfaitement ' (Cuvier, *Leçons*, i. 474).

[2] For ὥστε read πρὸς δέ. For νομίζειν read μεῖζον (Platt).

[3] For ἐσχισμένων read ἐσχισμένου. For συμβλάπτοιντο read ἂν βλάπτοιντο (Platt).

[4] That is, all the Mammalia known to him, with the exception of Cetacea.

Progression.[1] Irrespective of this absence of feet, serpents resemble the oviparous quadrupeds in their conformation.

In all these animals there is a head with its component parts; its presence being determined by the same causes [2] as obtain in the case of other sanguineous animals; and in all, with the single exception of the river crocodile, there is a tongue inside the mouth.[3] In this one exception there would seem to be no actual tongue, but merely a space left vacant for it. The reason is that a crocodile is in a way a land-animal and a water-animal combined. In its character of land-animal it has a space for a tongue; but in its character of water-animal it is without the tongue itself. For in some fishes, as has already been mentioned,[4] there is no appearance whatsoever of a tongue, unless the mouth be stretched open very widely indeed; while in others it is indistinctly separated from the rest of the mouth. The reason for this is that a tongue would be of but little service to such animals, seeing that they are unable to chew their food or to taste it before swallowing, the pleasurable sensations they derive from it being limited to the act of deglutition.[5] For it is in their passage down the gullet that solid edibles cause enjoyment, while it is by the tongue that the savour of fluids is perceived. Thus it is during deglutition that the oiliness, the heat, and other such qualities of food are

[1] *De An. Inc.* 8. 708a 9–20. See also iv. 13. 696a 10, where the explanation is repeated.

[2] Cf. iv. 10. 686a 5–18.

[3] There are, as a matter of fact, some oviparous quadrupeds without a tongue; but these are species which were unknown to Aristotle, such as the Carinthian Proteus, the Surinam Pipa, and the Dactylethra of South Africa. The crocodile really has a tongue; but it is flat, destitute of papillae, and united by its whole extent to the floor of the mouth. This seems to be recognized in other passages (*H. A.* ii. 10. 503a 1; *P. A.* ii. 17. 660b 15).

[4] Cf. ii. 17. 660b 13.

[5] That the sense of taste must be very dull in fishes is admitted by all naturalists (cf. Yarrell, *Brit. Fishes*, i. xvii); for, as A. justly observes, they do not chew their food, and thus the juices, which alone can excite true taste, are not expressed. Moreover, the inside of the mouth is being constantly washed over with water, which must of itself interfere with the possibility of any delicate gustation. Still they are probably not entirely without this sense, as is elsewhere (*H. A.* iv. 8. 533a 30) admitted; for, as there pointed out, they manifest certain preferences for one food rather than another.

recognized; and,[1] in fact, the satisfaction from most solid edibles and dainties is derived almost entirely from the dilatation of the oesophagus during deglutition.[2] This 691a sensation, then, belongs even to animals that have no[3] tongue, but while other animals have in addition the sensations of taste, tongueless animals have, we may say, no other[4] satisfaction than it. What has now been said explains why intemperance as regards drinks and savoury fluids does not go hand in hand with intemperance as regards eating and solid relishes.

In some oviparous quadrupeds, namely in lizards, the tongue is bifid,[5] as also it is in serpents,[6] and its terminal divisions are of hair-like fineness, as has already been described.[7] (Seals also have a forked tongue.) This it is which accounts for all these animals being so fond of dainty food.[8] The teeth in the four-footed Ovipara are of the sharp interfitting kind, like the teeth of fishes.[9] The organs of all the senses are present and resemble those of other animals. Thus there are nostrils for smell, eyes for vision, and ears for hearing. The latter organs, however, do not project from the sides of the head, but consist simply of the

[1] Transposing ἔχει . . . αἴσθησιν to after ἡ χάρις, and διό . . . ἐδωδήν to after ἡ ἑτέρα.

[2] 'On which account a certain gormandizer wished that his throat were longer than a crane's, implying that his pleasure was derived from the sense of touch' (*Ethics*, iii. 13. 1118a 32). The same notion led Spenser, in describing Gluttony, to say, 'And like a crane, his neck was long and fyne' (*Faëry Queen*, i. 4. 21).

[3] For ζῳοτόκα, substitute ἄγλωττα, as imperatively demanded by the context. A. did not suppose any vertebrate to be absolutely tongueless, not even the crocodile (ii. 17. 660b 25) though he calls it ἄγλωττος. In fishes, however, this part was almost rudimentary (ii. 17. 660b 14 note) and their sense of taste consequently very feeble.

[4] For ὡσπερανεί read ὥσπερ μόνη (Y).

[5] Cf. *H. A.* ii. 17. 508a 23. The tongue in Ophidia is bifid, as also it is in one great division of Sauria (hence called Fissilinguia or Leptiglossa), but not in all; not, for instance, in the chameleon nor in the wall gecko, or scarcely so, among species known to Aristotle. In the seal the tongue is deeply notched. See Buffon, *Nat. Hist.* xiii. pl 50.

[6] Read καί before οἱ ὄφεις (Y).

[7] Cf. ii. 17. 660b 9.

[8] For ἰσχνά read λίχνα (Karsch).

[9] The teeth of Saurian reptiles are usually acutely conical and slightly hooked. In some cases they are blade-like, and occasionally dentated on the edges. Rarely, as in Cyclodus, they have broad crushing crowns. In Chelonia there are no teeth whatsoever.

duct, as also is the case in birds. This is due in both cases to the hardness[1] of the integument; birds having their bodies covered with feathers, and these oviparous quadrupeds with horny plates. These plates are equivalent to scales, but of a harder character. This is manifest in tortoises and river crocodiles, and also in the large serpents. For here the plates become stronger than the bones,[2] being seemingly of the same substance as these.

These animals have no upper eyelid, but close the eye with the lower lid.[3] In this they resemble birds, and the reason is the same as was assigned in their case.[4] Among birds there are some[5] that can not only thus close the eye, but can also blink by means of a membrane which comes from its corner. But none of the oviparous quadrupeds blink;[6] for their eyes are harder than those of birds.[7] The reason for this is that keen vision and far-sightedness[8] are of very considerable service to birds, flying as they do in the air, whereas they would be of comparatively small use to the oviparous quadrupeds, seeing that they are all of troglodytic habits.

Of the two separate portions which constitute the head, namely the upper part and the lower jaw, the latter in man[9] and in the viviparous quadrupeds moves not only upwards and downwards, but also from side to side;[10] while in fishes,

[1] Cf. ii. 12; and ii. 13. 657b 5.

[2] All reptiles have horny epidermal scales, but not so such Amphibia as the frog and toad, which A. included in the same group. In the Chelonia and the crocodiles these scales are combined with bony scutes, and these animals are therefore known as Loricata. But nothing of the kind occurs in the large serpents, none of which were actually known to Aristotle, but of which he had probably heard fabulous accounts from some of Alexander's companions; from Nearchus, for instance, whose statement as to the existence of monstrous serpents in the East is quoted by Arrian in his *Indica*.

[3] Most reptiles have an upper eyelid, though they use the lower lid exclusively or preferentially. In Ophidia, however, and some Lacertilia, there are no lids at all, or rather the two lids are transparent and continuous with each other in front of the eye; a condition of things which A. supposed (ii. 13. 657b 32) to exist in Crustacea.

[4] Cf. ii. 13. 657b 5.

[5] Not some but all, as more correctly stated, *H. A.* ii. 12. 504a 26.

[6] This is an error (cf. ii. 13. 657b 23 note).

[7] And therefore, he implies, do not require so much protection.

[8] Reading ὀξυωπία καὶ τὸ πόρρω προϊδεῖν (U Y).

[9] Omitting οὖν (Y).

[10] The Carnivora are an exception, their teeth being adapted for

and birds and oviparous quadrupeds, the only movement is up and down. The reason is that this latter movement is the one required in biting and dividing food, while the 691b lateral movement serves to reduce substances to a pulp. To such animals, therefore, as have grinder-teeth this lateral motion is of service; but to those animals that have no grinders it would be quite useless, and they are therefore invariably without it. For nature never makes anything that is superfluous. While in all other animals it is the lower jaw that is movable, in the river crocodile it is exceptionally the upper.[1] This is because the feet in this creature are so excessively small as to be useless for seizing and holding prey; on which account nature has given it a mouth that can serve for these purposes in their stead. For that direction of motion which will give the greater force to a blow will be the more serviceable one in holding or in seizing prey; and a blow from above is always more forcible than one from below. Seeing, then, that both the prehension and the mastication of food are offices of the mouth, and that the former of these two is the more essential in an animal that has neither hands nor suitably formed feet, these crocodiles will derive greater benefit from a motion of the upper jaw downwards than from a motion of the lower jaw upwards. The same considerations explain why crabs also move the upper division of each claw and not the lower. For their claws are substitutes for hands, and so require to be suitable for the prehension of food, and not for its comminution; for such comminution and biting is the office of teeth. In crabs, then, and in such other animals as are able to seize their food in a leisurely manner, inasmuch as their mouth is not called on to perform its office while they are still in the water, the two functions are assigned to

cutting and not for grinding. This exception, though not mentioned here, is recognized presently, when it is said that lateral motion goes with grinding teeth only, and therefore not with the serrated dentition of Carnivora.

[1] This was the common belief of the ancients (cf. Herodotus, ii. 68). Cuvier thus accounts for the error: 'Les mâchoires inférieures se prolongeant derrière le crâne, il semble que la supérieure soit mobile, et les anciens l'ont écrit ainsi; mais il ne se meut qu'avec la tête toute entière' (*Règ. An.* ii. 18).

different parts, prehension to the hands or feet, biting and comminution of food to the mouth. But in crocodiles the mouth has been so framed by nature as to serve both purposes, the jaws being made to move in the manner just described.

Another part present in these animals is a neck, this being the necessary consequence of their having a lung. For the windpipe by which the air is admitted to the lung is of some length.[1] If, however, the definition of a neck be correct, which calls it the portion between the head and the shoulders, a serpent can scarcely be said with the same right as the rest of these animals to have a neck, but only to have something analogous to that part of the body. It is a peculiarity of serpents, as compared with other animals 692a allied to them, that they are able to turn their head backwards without stirring the rest of the body. The reason of this is that a serpent, like an insect, has a body that admits of being curled up, its vertebrae being cartilaginous and easily bent.[2] The faculty in question belongs then to serpents simply as a necessary consequence of this character of their vertebrae; but at the same time it has a final cause, for it enables them to guard against attacks from behind. For their body, owing to its length and the absence of feet, is ill-suited for turning round and protecting the hinder parts; and merely to lift the head, without the power of turning it round, would be of no use whatsoever.

The animals with which we are dealing have, moreover, a part which corresponds to the breast; but neither here nor elsewhere in their body have they any mammae, as neither has any bird or fish. This is a consequence of their having no milk; for a mamma is a receptacle for milk and, as it were, a vessel to contain it. This absence of milk is not peculiar to these animals, but is common to all such as are not internally viviparous.[3] For all such produce eggs, and the

[1] Cf. iii. 3. 664a 30 note.

[2] The vertebrae of Ophidia are not cartilaginous but osseous. The great flexibility of the spine is due to its division into excessively numerous segments, and to the existence of a perfect ball and socket joint between each of these and that which precedes and follows it.

[3] 'Internally viviparous' is equivalent to Mammalia, whose ovum

nutriment which in Vivipara has the character of milk is in them engendered in the egg. Of all this, however, a clearer account will be given in the treatise on Generation.[1] As to the mode in which the legs[2] bend, a general account, in which all animals are considered, has already been given in the dissertation on Progression.[3] These animals also have a tail, larger in some of them, smaller in others, and the reason for this has been stated in general terms in an earlier passage.[4]

Of all oviparous animals that live on land there is none so lean as the Chamaeleon. For there is none that has so little blood. The explanation of this is to be found in the psychical temperament of the creature. For it is of a timid nature, as the frequent changes it undergoes in its outward aspect testify.[5] But fear is a refrigeration, and results from deficiency of natural heat and scantiness of blood.

We have now done with such sanguineous animals as are 692b
quadrupedous and also such as are apodous, and have stated with sufficient completeness what external parts they possess, and for what reasons they have them.

12 The differences of birds compared one with another are differences of magnitude, and of the greater or smaller development of parts. Thus some have long legs, others short legs; some have a broad tongue, others a narrow tongue; and so on with the other parts. There are few of their parts that differ save in size,[6] taking birds by themselves. But when birds are compared with other animals the parts present differences of form also. For in some animals these are

was unknown to Aristotle; it excludes ovoviviparous animals, which A. called 'externally viviparous but internally oviparous.'

[1] *G. A.* iii. 2. 752b 15 sqq.

[2] For καμπύλων read σκελῶν (P).

[3] Cf. *De An. Inc.* 13.

[4] Cf. iv. 10. 689b 3–690a 4.

[5] Alluding of course to the well-known changes of colour that occur in this animal (cf. Owen, *Verteb.* i. 556), which are apparently determined not only by variations in the temperature, the amount of light, and the tints of surrounding objects, but also by emotions, as fear, anger, and the like.

[6] The sense requires πλὴν κατὰ μέγεθος or equivalent words after ἀλλήλων. The class Aves is remarkably homogeneous. 'The structural modifications which they present are of comparatively little importance' (Huxley).

hairy, in others scaly, and in others have scale-like plates, while birds are feathered.

Birds, then, are feathered,[1] and this is a character common to them all and peculiar to them. Their feathers, too, are split and distinct in kind from the undivided feathers of insects; for the bird's feather is barbed, these are not; the bird's feather has a shaft, these have none.[2]

A second strange peculiarity which distinguishes birds from all other animals is their beak. For as in elephants[3] the nostril serves in place of hands, and as in some insects the tongue serves in place of mouth, so in birds there is a beak, which, being bony,[4] serves in place of teeth and lips. Their organs of sense have already been considered.[5]

All birds have a neck extending from the body; and the purpose of this neck is the same as in such other animals as have one. This neck in some birds is long, in others short; its length, as a general rule, being pretty nearly determined by that of the legs. For long-legged birds have a long neck, short-legged birds a short one, to which rule, however, 693a the web-footed birds form an exception. For to a bird perched up on long legs a short neck would be of no use whatsoever in collecting food from the ground; and equally useless would be a long neck, if the legs were short. Such birds, again, as are carnivorous would find length in this part interfere[6] greatly with their habits of life. For a long neck is weak, and it is on their superior strength that carnivorous birds depend for their subsistence. No bird, therefore, that has talons ever has an elongated neck. In web-footed birds, however, and in those other birds[7] belonging

[1] Transpose πτερωτοί . . . τῶν ἄλλων, placing it after the next sentence.

[2] Cf. iv. 6. 682b 17 note.

[3] Cf. ii. 16. 658b 33.

[4] Read ὀστινον ὄν (Y). Not, however, actually bony, but resembling bone in being hard. Cf. ii. 9. 655b 3.

[5] Cf ii. 12–17.

[6] Read ὑπεναντίον ἂν ἦν τό (P Y b).

[7] Read καὶ τὰ διῃρημένους, and for ὡς ἐν τῷ read καὶ ἐν τῷ. The birds alluded to are the Grebes, Phalaropes, and Coots (the Pinnatipedes of Temminck), in which the toes, as described more distinctly farther on, are bordered with broad membranous lobes. The word in the Greek text (σεσιμωμένους), rendered 'with flat marginal lobes', is literally 'snub-nosed'; the main stem of the toe answering to the ridge of the nose, and the lobes on either side to the flattened nostrils.

to the same class, whose toes though actually separate have flat marginal lobes, the neck is elongated, so as to be suitable for collecting food from the water; while the legs are short, so as to serve in swimming.

The beaks of birds, as their feet, vary with their modes of life. For in some the beak is straight, in others crooked; straight, in those who use it merely for eating; crooked, in those that live on raw flesh. For a crooked beak is an advantage in fighting; and these birds must, of course, get their food from the bodies of other animals, and in most cases by violence. In such birds, again, as live in marshes and are herbivorous the beak is broad and flat, this form being best suited for digging and cropping, and for pulling up plants. In some of these marsh birds, however, the beak is elongated, as too is the neck, the reason for this being that the bird gets its food from some depth below the surface. For most birds of this kind, and most of those whose feet are webbed, either in their entirety or each part separately,[1] live by preying on some of the smaller animals that are to be found in water, and use these parts for their capture, the neck acting as a fishing-rod, and the beak representing the line and hook.

The upper and under sides of the body, that is of what in quadrupeds is called the trunk, present in birds one unbroken surface, and they have no arms[2] or forelegs attached to it, but in their stead wings, which are a distinctive peculiarity of these animals; and, as these wings are sub- 693b
stitutes for arms, their terminal segments lie on the back in the place of a shoulder-blade.[3]

The legs are two in number, as in man; not however, as in man, bent outwards, but bent inwards like the [hind] legs of a quadruped.[4] The wings are bent like the forelegs of

[1] The sense is obvious (see last note), but the true meaning doubtful. I suggest omitting *τό* with Y and for *ταὐτό* reading *τούτοις*, meaning the elongated neck and beak.

[2] Read *καὶ ἔχουσι ἀπηρτημένας*, omitting *ἔχουσι* after *προσθίων* (Y b).

[3] The scapula in birds is a simple elongated bone, not flattened out into a plate or blade, and so was not recognized by A. as a 'blade-bone', just as he did not recognize the astragalus unless it had the form suiting it for use as a 'huckle-bone'.

[4] Cf. *H. A.* ii. 1. 498^a 27; *De An. Inc.* 15. 712^b 22 sq. A. uses two sets

a quadruped, having their convexity turned outwards. That the feet should be two in number is a matter of necessity. For a bird is essentially a sanguineous animal, and at the same time essentially a winged animal; and no sanguineous animal has more than four points for motion.[1] In birds, then, as in those other sanguineous animals that live and move upon the ground, the limbs attached to the trunk are four in number. But, while in all the rest these four limbs consist of a pair of arms and a pair of legs,[2] or of four legs as in quadrupeds, in birds the arms or forelegs are replaced by a pair of wings, and this is their distinctive character. For it is of the essence of a bird that it shall be able to fly; and it is by the extension of wings that this is made possible. Of all arrangements, then, the only possible, and so the necessary, one is that birds shall have two feet; for this with the wings will give them four points for motion. The breast in all birds is sharp-edged, and fleshy.[3] The sharp edge is to minister to flight, for broad surfaces move with considerable difficulty, owing to the large quantity of air which they have to displace; while the fleshy character

of terms to describe the bendings of the limbs: (1) Forwards and backwards, (2) Inwards and outwards. A limb is said to be bent forwards or backwards when its convexity is turned forwards or backwards; e.g. the leg of a man is bent forwards; so is the foreleg of a horse. But the hind leg of a horse is bent backwards; the arm of a man is bent backwards with a slight inclination to the side. A limb is bent inwards, when its concavity is turned in the direction in which the main bulk of the body lies; outwards when the concavity is turned away from this. Thus both the fore and hind legs of a horse are bent inwards. So also the leg of a bird is bent inwards; but the leg of a man is bent outwards. Cf. *H. A.* ii. 1. 498a 3–31; *De An. Inc.* 12–15.

It must be remembered that A. knows nothing of the homologies of the various joints. He simply takes the limbs as wholes, and compares the general direction of their main curvature in different animals.

[1] A. rightly says that no sanguineous animal has more than four organs of locomotion, that is, more than four limbs. There are passages from which it might be inferred that he imagined, less correctly, that they never have less than four. But in the *De An. Inc.* (10. 709b 22) he expressly repudiates such a statement.

[2] Reading *σκέλη τοῖς δὲ τετράποσι σκέλη* (PY).

[3] A. had clearly neither dissected, nor seen the skeleton of, an ostrich. In all other birds known to him the sternum is provided with a keel, and is compared by him (*De An. Inc.* 10. 710a 31) to the sharp prow of a felucca, reminding one of the term 'Carinatae' now applied to birds with a keeled sternum. By the fleshy covering is of course meant the mass of pectoral muscles.

acts as a protection, for the breast, owing to its form, would be weak, were it not amply covered.

Below the breast lies the belly, extending, as in quadrupeds and in man, to the vent and to the place where the legs are jointed to the trunk.

Such, then, are the parts which lie between the wings and the legs. Birds like all other animals, whether produced viviparously or from eggs, have an umbilicus during their development, but, when the bird has attained to fuller growth, no signs of this remain visible. The cause of this is plainly to be seen during the process of development; for in birds the umbilical cord unites with the intestine, and is not a portion of the vascular system, as is the case in viviparous animals.[1]

Some birds, again, are well adapted for flight, their wings being large and strong. Such, for instance, are those that 694a
have talons and live on flesh. For their mode of life renders the power of flight a necessity, and it is on this account that their feathers are so abundant and their wings so large. Besides these, however, there are also other genera of birds that can fly well; all those, namely, that depend on speed for security, or that are of migratory habits. On the other hand, some kinds of birds have heavy bodies and are not constructed for flight. These are birds that are frugivorous and live on the ground, or that are able to swim and get

[1] It might be supposed from this passage that A. imagined a bird to be developed without an allantois and merely with an umbilical vesicle. But from other passages (*G. A.* iii. 3. 754b 4; *G. A.* iii. 2. 753b 20 sq.; *H. A.* vi. 3. 561b 5) it is plain that this was not the case. He describes the foetal bird and reptile as differing from fishes in having two umbilical appendages, one going to the membrane surrounding the yelk, and serving to introduce the nutriment thence derived, the other (*allantois*) to the membranous expansion which lines the inner surface of the shell. This latter appendage, he says, collapses as the embryonic bird enlarges; while the former with the yelk is drawn back into the abdominal cavity, the walls of which unite together behind it. He had not observed the umbilical vesicle of mammals, which is comparatively small, and shrivels up at an early period of foetal life, and erroneously supposed their allantois to correspond to the umbilical vesicle of birds and reptiles. This error was not corrected till 1667, when Needham discovered the umbilical vesicle of mammals, and recognized its correspondence to that of birds. Neither had A. observed that Amphibia in this matter resemble fishes and not reptiles, with which latter he grouped them.

their living in watery places. In those that have talons the body, without the wings, is small; for the nutriment is consumed in the production of these[1] wings, and of the weapons and defensive appliances; whereas in birds that are not made for flight the contrary obtains, and the body is bulky and so of heavy weight. In some of these heavy-bodied birds the legs are furnished with what are called spurs, which replace the wings as a means of defence. Spurs and talons never co-exist in the same bird. For nature never makes anything superfluous; and if a bird can fly, and has talons, it has no use for spurs; for these are weapons for fighting on the ground, and on this account are an appanage of certain heavy-bodied birds. These latter, again, would find the possession of talons not only useless but actually injurious; for the claws would stick into the ground and interfere with progression. This is the reason why all birds with talons walk so badly, and why they never settle upon rocks.[2] For the character of their claws is ill-suited for either action.

All this is the necessary consequence of the process of development. For the earthy matter in the body issuing[3] from it is converted into parts that are useful as weapons. That which flows upwards gives hardness or size to the beak; and, should any flow downwards, it either forms spurs upon the legs or gives size and strength to the claws upon the feet. But it does not at one and the same time produce both these results, one in the legs, the other in the claws; for such a dispersion of this residual matter would destroy all its efficiency. In other birds this earthy residue furnishes
694b the legs with the material for their elongation; or sometimes, in place of this, fills up the interspaces between the

[1] For ἐνταῦθα read εἰς ταύτας (Q S U Z); and read καί before εἰς τὰ ὅπλα.

[2] Birds of prey are awkward movers on the ground or other flat surface, because of their talons, and help themselves along by flapping their wings. But the statement made here and elsewhere (*H. A.* ix. 32. 619b 7) that they very seldom or never settle on rocks is erroneous; they often do so, and indeed rocks are the usual resting-place of many. Moreover, in the Falconidae the claws are retractile, so that they can be elevated at pleasure, and their sharp ends kept from being blunted by contact with any hard body on which the bird may perch.

[3] If the strange word ἔξορμον be kept, we may read ἔξορμον ἐκ τούτου τά (Y), and suppose the earthy matter making its way out of the body to be compared metaphorically to a ship making its way out of a harbour, but Langkavel's suggested reading ἔξω ῥυέν is very probable.

toes. Thus it is simply a matter of necessity,[1] that such birds as swim shall either be actually web-footed, or shall have a kind of broad blade-like margin running along the whole length of each distinct toe. The forms, then, of these feet are simply the necessary results of the causes that have been mentioned. Yet at the same time they are intended for the animal's advantage. For they are in harmony with the mode of life of these birds, who, living on the water, where their wings[2] are useless, require that their feet shall be such as to serve in swimming. For these feet are so developed as to resemble the oars of a boat, or the fins[3] of a fish; and the destruction of the foot-web has the same effect as the destruction of the fins; that is to say, it puts an end to all power of swimming.

In some birds the legs are very long, the cause of this being that they inhabit marshes. I say the cause, because nature makes the organs for the function, and not the function for the organs. It is, then, because these birds are not meant for swimming that their feet are without webs, and it is because they live on ground that gives way under the foot that their legs and toes are elongated, and that these latter in most of them have an extra number of joints.[4] Again, though all birds have the same material composition, they are not all made for flight; and in these, therefore, the nutriment that should go to their tail-feathers is spent on the legs and used to increase their size. This is the reason why these birds when they fly make use of their legs as a tail, stretching them out behind, and so rendering them serviceable, whereas in any other position they would be simply an impediment.[5]

[1] Because the earthy matter has not been used in any other manner, and must be disposed of in some way or other.

[2] For πτερῶν read πτερύγων (Y b).

[3] Read καί before τὰ πτερύγια τοῖς ἰχθύσιν (Y b).

[4] This is erroneous. The number of phalanges is the same in the several toes of Waders as in other birds, though the toes are as a rule longer.

[5] 'These water birds fly with their legs stretched out behind, using them in place of a tail to steer their course.' In the heron, for instance, the tail is short, and the long legs, stretched out in flight, 'seem, like the longer tails of some birds, to serve as a rudder' (Bewick's *Birds*, p. 11).

In other birds, where the legs are short, these are held close against the belly during flight. In some cases this is merely to keep the feet out of the way, but in birds that have talons the position has a further purpose, being the one best suited for rapine. Birds that have a long and a thick neck keep it stretched out during flight; but those whose neck though long is slender fly with it coiled up. For in this position it is protected, and less likely to get broken, should the bird fly against any obstacle.[1]

695a In all birds there is an ischium,[2] but so placed and of such length that it would scarcely be taken for an ischium, but rather for a second thigh-bone; for it extends as far as to the middle of the belly. The reason for this is that the bird is a biped, and yet is unable to stand erect. For if its ischium extended but a short way from the fundament, and then immediately came the leg, as is the case in man and in quadrupeds, the bird would be unable to stand up at all.[3] For while man stands erect, and while quadrupeds have their heavy bodies propped up in front by the forelegs, birds can neither stand erect owing to their dwarf-like shape, nor have anterior legs to prop them up, these legs being replaced by wings.[4] As a remedy for this Nature has given them a long ischium, and brought it to the centre of the body, fixing it firmly; and she has placed the legs under this central point, that the weight on either side may be equally balanced, and standing or progression rendered possible. Such then is the reason why a bird, though it is a biped, does not stand erect. Why its legs[5] are destitute of flesh has also already been stated;[6] for the reasons are the same as in the case of quadrupeds.

[1] The heron in flight rests its very slender neck and head on the back, so that the bill appears to issue from the chest; while the stork, the ibis, the goose, &c., fly with the comparatively stout neck outstretched.

[2] A. uses the term 'ischium' in two senses; firstly, for the fleshy buttocks, and it is with this meaning that he says (iv. 10. 690a 25) that man alone has ischia; secondly, for the bone with which the femur in man, and what he mistakes for the femur in other vertebrates, is articulated at its upper end; and it is with this meaning that he says that birds have long ischia. (Cf. iv. 10. 689b 7 note.)

[3] For ὀρθὸν read ὅλως (P Q U).

[4] Read διὰ τοῦτο, πτέρυγας δὲ ἀντ' αὐτῶν (Y).

[5] By σκέλη here are plainly meant not the whole legs, but their tarso-metatarsal segments.

[6] Cf. iv. 10. 689b 7.

In all birds alike, whether web-footed or not, the number of toes in each foot is four.[1] For the Libyan ostrich may be disregarded for the present, and its cloven hoof and other discrepancies of structure as compared with the tribe of birds will be considered further on.[2] Of these four toes three are in front, while the fourth points backwards, serving, as a heel, to give steadiness. In the long-legged birds this fourth toe is much shorter[3] than the others, as is the case with the Crex,[4] but the number of their toes is not increased.[5] The arrangement of the toes is such as has been described in all[6] birds with the exception of the wryneck. Here only two of the toes are in front,[7] the other two behind; and the reason for this is that the body of the wryneck is not inclined forward so much as that of other birds. All birds have testicles; but they are inside the body. The reason for this will be given in the treatise on the Generation of Animals.[8]

13 Thus then are fashioned the parts of birds. But in fishes 695b
a still further stunting has occurred in the external parts. For here, for reasons already given,[9] there are neither legs nor hands nor wings, the whole body from head to tail presenting one unbroken surface. This tail differs in different fishes, in some approximating in character to the fins,[10] while in others, namely in some of the flat kinds, it is spinous and elongated, because the material which should have gone to

[1] This is a general but not universal rule. In some birds, as the great bustard, the Otis of Aristotle, the toes are reduced to three by suppression of the hallux, as in the ostrich they are reduced to two by suppression of both hallux and second digit. [2] Cf. iv. 14.

[3] The hind toe varies very much in its development in Waders. Usually it is short, as A. correctly says, but sometimes it is as long as, or even longer than, the others.

[4] The Crex was doubtless some bird that derived its name, as does our corn-crake, from its note. But it is uncertain what exact species was thus designated. Cf. D'Arcy Thompson, *Greek Birds*, p. 103.

[5] Although such increase might perhaps have been expected by way of compensation.

[6] Elsewhere (*H. A.* ii. 12. 504a 11) A. says, more correctly, that there are several exceptions besides the wryneck.

[7] Transpose ὄπισθεν and ἔμπροσθεν (Karsch).

[8] *G. A.* i. 4. 717b 4, i. 12.

[9] I cannot say to what passage A. refers. But his explanation of the substitution of fins for limbs is given a little further on in this chapter. See 695b 17.

[10] After παραπλησίαν, by itself unmeaning, read τοῖς πτερυγίοις.

the tail has been diverted thence and used to increase the breadth of the body. Such, for instance, is the case with the Torpedos,[1] the Trygons, and whatever other Selachia there may be of like nature. In such fishes, then, the tail is spinous and long; while in some others it is short and fleshy, for the same reason which makes it spinous and long in the Torpedo. For to be short and fleshy comes to the same thing as to be long and less amply furnished with flesh.

What has occurred in the Fishing-frog [2] is the reverse of what has occurred in the other instances just given. For here the anterior and broad part of the body is not of a fleshy character, and so all the fleshy substance which has been thence diverted has been placed by nature in the tail and hinder portion [3] of the body.

In fishes there are no limbs attached to the body. For in accordance with their essential constitution they are swimming animals; and nature never makes anything superfluous or void of use. Now inasmuch as fishes are made for swimming they have fins,[4] and as they are not made for

[1] The electric rays or Torpedos are found abundantly in the Mediterranean, and must have been well known to A., who frequently speaks of them. Yet in these the tail is far from being spinous and elongated, as compared, that is, with other rays. Frantzius suggests therefore that some error has got into the text, and that perhaps Batos should be read instead of Torpedo. A similar correction would have to be made a few lines farther on. The Trygon is doubtless the *Trygon Pastinaca* or sting-ray, which is abundant in the Mediterranean.

[2] The Fishing-frog (*Lophius piscatorius* or *L. budegassa*) was erroneously classed by A. with Selachia, confounding it with the rays. Into this error he was doubtless led by the somewhat ray-like form of this fish, by the semi-cartilaginous character of its skeleton (Cuvier, *R. An.* iii. 250), and by its naked skin, rough with warts and tubercles. A. did not, however, fail to observe that this fish differed in many important points from the rest of the group; in being, for instance, oviparous (*G. A.* iii. 3. 754a 25); and in having an operculum for its gills, which are themselves placed laterally, not ventrally as in true rays (*H. A.* ii. 13. 505a 5).

[3] For *αὐτό* read *αὐτῶν* (U).

[4] Although A. recognizes the correspondence of the paired fins (i. e. pectorals and ventrals) of fishes to the four limbs of other vertebrates, this recognition is not based on any serious anatomical grounds, as is plain from what he says of the Rays. For he fails to see that the marginal parts of the flattened bodies of these fishes are really the pectorals, but supposes these to have been moved back and to be represented by the (*dorsal*) fins on the tail, which in many rays are two in number. So also he speaks of the serpents, which have no limbs at all, as still resembling the other sanguineous animals, i. e. in having four points of motion. 'For,' says he, 'their flexures are four,' while

walking they are without feet; for feet are attached to the body that they may be of use in progression on land. Moreover, fishes cannot have feet, or any other similar limbs, as well as four fins; for they are essentially sanguineous animals. The Cordylus,[1] though it has gills, has feet, for it has no fins but merely has its tail flattened out and loose in texture.[2]

Fishes, unless, like the Batos and the Trygon, they are broad and flat, have four fins, two on the upper and two on 696^a the under side of the body; and no fish ever has more than these. For, if it had, it would be a bloodless animal.

The upper pair of fins is present in nearly all fishes, but not so the under pair;[3] for these are wanting in some of those fishes that have long thick bodies, such as the eel, the conger, and a certain kind of Cestreus that is found in the lake at Siphae. When the body is still more elongated, and resembles that of a serpent rather than that of a fish, as is the case in the Smuraena,[4] there are absolutely no fins at all; and locomotion is effected by the flexures of the body, the water being put to the same use by these fishes as is the ground by serpents. For serpents swim in water exactly in the same way as they glide on the ground. The reason for these serpent-like fishes being without fins is the same as that which causes serpents to be without feet; and what

in such fishes as have only two fins 'the flexures are two, to replace the missing pair' (cf. *H. A.* i. 5. 490^a 30).

[1] Cf. *H. A.* viii. 2. 589^b 26. The Cordylus must presumably be the larval form of some triton or newt which retains its gills for a longer period than the generality of tadpoles. Such, says Prof. D'Arcy Thompson, are *Triton alpestris* and *Salamandra atra*. It is strange that A. should not have known that tadpoles are the larval forms of frogs and newts.

[2] Destitute, that is, of fin-rays.

[3] The pectoral fins are, as rightly stated in the text, much more constant than the ventral pair. Even in those elongated eels in which no pectorals are visible externally, rudiments of them are to be found on dissection; whereas not only are the ventral fins more often externally wanting than the pectorals, but their absence is often complete, no rudiment of them appearing on dissection, e. g. in Muraena, Muraenophis, Gymnotus, &c. There are pectoral, but no ventral, fins in the eel, the conger, and the rest of the so-called Apodal Physostomatous fishes. As to the Cestreus, it is impossible to say what fish is here meant. It can scarcely be one of the Mugilidae, though these are the fishes usually called Cestreus by Aristotle.

[4] The Smuraena and Muraena are probably one and the same fish, namely the *Muraena Helena*, common in the Greek seas, and still, according to Erhard, called Smurna or Sphurna.

this is has been already stated in the dissertations on the Progression and the Motion of Animals.[1] The reason was this. If the points of motion were four, motion would be effected under difficulties; for either the two pairs of fins would be close to each other, in which case motion would scarcely be possible, or they would be at a very considerable distance apart, in which case the long interval between them would be just as great an evil. On the other hand, to have more than four such motor points would convert the fishes into bloodless animals. A similar explanation applies to the case of those fishes that have only two fins. For here again the body is of great length and like that of a serpent, and its undulations [2] do the office of the two missing fins. It is owing to this that such fishes can even crawl on dry ground, and can live there for a considerable time; and do not begin to gasp until they have been for a considerable time out of the water, while others, whose nature is akin to that of land-animals, do not even do as much as that.[3] In such fishes as have but two fins it is the upper pair (*pectorals*) that is present, excepting when the flat broad shape of the body prevents this. The fins in such cases are placed at the head, because in this region there is no elongation, which might serve in the absence of fins as a means of locomotion; whereas in the direction of the tail there is a considerable lengthening out in fishes of this conformation. As for the Bati and the like, they use the marginal part of their flattened bodies in place of fins for swimming.[4]

In the Torpedo and the Fishing-frog the breadth of the anterior part of the body is not so great as to render locomotion by fins impossible, but in consequence of it the upper pair (*pectorals*) are placed further back and the under pair (*ventrals*) are placed close to the head, while to compensate for this advancement they are reduced in size so as to be smaller than the upper ones.[5] In the Torpedo the

[1] Cf. *De An. Inc.* 7. 709^b 7 sqq. There is no corresponding passage in the *De Motu*. Moreover, that treatise is universally admitted to be spurious. Possibly A. is merely using a longer title than usual to designate his treatise on Progression. [2] See 695^b 20 note.

[3] The text here is so corrupt as only to admit of somewhat conjectural rendering.

[4] The Rays swim as here described. See, however, 695^b 20 note.

[5] In the Fishing-frog the ventral fins are, as stated, in advance of

two upper fins (*pectorals*) are placed on the tail,[1] and the fish uses the broad expansion of its body to supply their place, each lateral half of its circumference serving the office of a fin.

The head, with its several parts, as also the organs of sense, have already come under consideration.[2]

There is one peculiarity which distinguishes fishes from all other sanguineous animals, namely, the possession of gills. Why they have these organs has been set forth in 696^b
the treatise on Respiration.[3] These gills are in most fishes covered by opercula, but in the Selachia, owing to the skeleton being cartilaginous, there are no such coverings. For an operculum requires fish-spine for its formation, and in other fishes the skeleton is made of this substance, whereas in the Selachia it is invariably formed of cartilage. Again, while the motions of spinous fishes are rapid, those of the Selachia are sluggish, inasmuch as they have neither fish-spine nor sinew; but an operculum requires rapidity of motion, seeing that the office of the gills is to minister as it were to expiration.[4] For this reason in Selachia the branchial orifices themselves effect their own closure, and thus there is no need for an operculum to ensure its taking place with due rapidity.[5] In some fishes the gills are numerous, in others few in number; in some again they are double, in others single. The last gill in most cases is single.[6] For

the pectorals and smaller than these. It is quite true that when the ventrals are advanced forwards, so as to become jugular, they are as a rule, if not invariably, reduced in size; and they are also, as a rule, modified in such a way as to serve new purposes, to act, for instance, as instruments of touch. Cf. *Ann. d. Sci. Nat.*, 1872, t. xvi. p. 93.

[1] Cf. 695^b 20 note.

[2] Namely, in the latter part of the second book and beginning of the third book.

[3] *De Resp.* 10. 476^a 1 sq., and 21. 480^b 13.

[4] A. says, minister 'as it were' to expiration; for expiration is limited by him to the expulsion of air from a lung after inspiration. The expulsion of water through gills is analogous to this, but not the same thing.

[5] In these cartilaginous fishes there is no gill-cover; the gills being placed in a series of distinct sacs or pouches, each of which has its own separate slit-like aperture, which is closed during inhalation by its own muscular sphincter.

[6] In the Elasmobranchii or cartilaginous fishes there are five, and in osseous fishes four, gills on either side as a rule. But the number is subject to some variations. Each gill consists, as a rule, of a double row of leaflets. But it is by no means uncommon for the last, that is the fourth, gill in an osseous fish to be, as A. says, furnished with only a single row, e.g. Scarus, Scorpaena, Cottus, most Labroids, &c.

a detailed account of all this, reference must be made to the treatises on Anatomy, and to the book of Researches concerning Animals.[1]

It is the abundance or the deficiency of the cardiac heat which determines the numerical abundance or deficiency of the gills. For, the greater an animal's heat, the more rapid and the more forcible does it require the branchial movement to be;[2] and numerous and double gills act with more force and rapidity than such as are few and single. Thus, too, it is that some fishes that have but few gills, and those of comparatively small efficacy, can live out of water for a considerable time; for in them there is no great demand for refrigeration. Such, for example, are the eel and all other fishes of serpent-like form.

Fishes also present diversities as regards the mouth. For in some this is placed in front, at the very extremity of the body, while in others, as the dolphin[3] and the Selachia, it is placed on the under surface; so that these fishes turn on the back in order to take their food. The purpose of Nature in this was apparently not merely to provide a means of salvation for other animals, by allowing them opportunity of escape during the time lost in the act of turning—for all the fishes with this kind of mouth prey on living animals—but also to prevent these fishes from giving way too much to their gluttonous ravening after food.[4] For had they been

[1] Cf. *H. A.* ii. 13. 504b 28–505a 20.

[2] Because the hotter an animal is, the more perfect must be the arrangements for its refrigeration.

[3] Seeing that dolphins abound in the Mediterranean, and that the main points in their structure, and their habits of life, are accurately enough described by Aristotle, it seems to me quite impossible either that he can have imagined their mouth to be underneath their body, or, as has been suggested, confounded them with the larger sharks. I agree therefore with Frantzius that the word dolphins in the text is probably an interpolation; and this notwithstanding the objection to that view taken by Meyer, namely, the fact that the same false statement occurs elsewhere (*H. A.* viii. 2. 591b 26). The same transcriber who made the addition to the text in the one place may very possibly have made it in the other.

[4] This is, so far as I know, the only place where A. speaks of the structure of an animal as intended for the advantage of other animals than itself. Elsewhere he always speaks of the organs as given to animals to be of service to themselves. 'Nature never gives an organ to an animal except when it is able to make use of it.' Even here he considers the habit in question to be of use to its possessor, and only speaks doubtfully of its being intended as a means of salvation to others.

able to seize their prey more easily than they do, they would soon have perished from over-repletion. An additional reason is that the projecting extremity of the head in these fishes is round and small, and therefore cannot admit of a wide opening.

Again, even when the mouth is not placed on the under surface, there are differences in the extent to which it can open. For in some cases it can gape widely, while in others
it is set at the point of a small tapering snout; the former 697a
being the case in carnivorous fishes, such as those with sharp interfitting teeth, whose strength lies in their mouth, while the latter is its form in all such as are not carnivorous.

The skin is in some fishes covered with scales (the scale of a fish is a thin and shiny film, and therefore easily becomes detached from the surface of the body[1]). In others it is rough, as for instance in the Rhine, the Batos[2], and the like. Fewest of all are those whose skin is smooth. The Selachia have no scales, but a rough skin. This is explained by their cartilaginous skeleton. For the earthy material which has been thence diverted is expended by nature upon the skin.

No fish has testicles[3] either externally or internally; as indeed have no apodous animals, among which of course are

[1] This parenthesis appears to be a note introduced to point out the difference between the scale of a fish (λεπίς) and the scale of a reptile (φολίς); the former thin and quite superficial, so as to be easily rubbed off, the latter thicker and set more firmly in the skin. It is strange that λαμπρότης should be assigned as a cause of easy detachment, unless 'shiny' is supposed to connote 'superficial'. Perhaps, however, for λαμπρότητα should be read μαλακότητα.

[2] The Batus is indisputably a Ray. The Rhine is usually identified with the Angel-fish (*R. Squatina*), but much more probably is some other shark in shape like a dog-fish; while the Angel-fish is the Rhinobates, said (*H. A.* vi. 11. 566a 28) to be in the fore part like the Batus and in the hind part like the Rhine, and supposed to be a cross between the two. It 'has a form and appearance intermediate between the Sharks and Rays' (Seeley).

[3] That is to say they have no solid organ of the globular or ovoid shape which characterizes the testes of Mammalia, birds, and most reptiles. This is all that A. can mean; for he was perfectly aware that the milt was an organ from which the male fish secreted sperm; and he states, in opposition to those who held that there were no males among osseous fishes, that the ova of the female fish come to nothing unless the male voids the secretion of this milt upon them (*G. A.* iii. 1. 750b 15; *H. A.* vi. 14. 568b 6). He refuses, however, to call these saccular organs 'testes', because of their shape and of their being hollow, and styles them spermatic tubes (πόροι) or roe (θορικά). He supposed (*G. A.* i. 4) that these saccular spermatic tubes or roe, as

included the serpents. One and the same orifice serves both for the excrement and for the generative secretions,[1] as is the case also in all other oviparous animals, whether two-footed or four-footed,[2] inasmuch as they have no urinary bladder and form no fluid excretion.[3]

Such then are the characters which distinguish fishes from all other animals. But dolphins and whales and all such Cetacea are without gills; and, having a lung, are provided with a blow-hole; for this serves them to discharge the sea-water which has been taken into the mouth.[4] For, feeding as they do in the water, they cannot but let this fluid enter into their mouth, and, having let it in, they must of necessity let it out again. The use of gills, however, as has been explained in the treatise on Respiration,[5] is limited to such animals as do not breathe; for no animal can possibly possess gills and at the same time be a respiratory animal. In order, therefore, that these Cetacea may discharge the water, they are provided with a blow-hole. This

also the elongated testes of serpents, corresponded not to the solid globular or ovoid organs of birds, reptiles, and mammals, but to the tubular *vasa deferentia*; and it was to these latter that he erroneously ascribed the seminal secretion. The ovoid or globular bodies he thought were merely parts superadded, when the secreting spermatic tubes became very long and complicated, for certain mechanical purposes, which are set forth by him. His account of the seminal organs of fishes seems to have been taken from osseous fishes; for in the rays and sharks, that is to say in his Selachia, the testes are compact oval bodies (cf. Huxley, *Vert.* p. 135).

[1] In birds, reptiles, amphibians, there is a cloaca, i.e. a common chamber into which open the rectum and the genital organs, as also the urinary, though the latter escaped A.'s notice. Thus in these animals the faeces and the generative products are voided by one and the same orifice. There is also a cloaca in the Plagiostomous fishes, or Selachia of Aristotle. But though the statement in the text so far is true, it is erroneous as regards other fishes. For in these the anus is distinct from the generative orifice or abdominal pore.

[2] Read *καὶ δίποδα καὶ τετράποδα.*

[3] The meaning must be: 'If there were urinary organs and external urinary orifice, the generative secretions would be discharged by this. But as there is none, these secretions are discharged by the anus.'

[4] The like statement is often enough made nowadays, but is incorrect. The sea-water taken into the mouth has no access to the respiratory passages and blow-hole, owing to the peculiar arrangement by which the elongated trachea and larynx are continuous with the tubular prolongation of the nasal passage formed by the soft palate. The 'spouting' is due to the sudden condensation of expired vapour, and to spray driven up by the force of the expiration, when this begins before the animal has quite reached the surface.

[5] *De Resp.* 10. 476^a 1 sq.; 21. 480^b 13.

is placed in front of the brain; for otherwise it would have cut off the brain from the spine.[1] The reason for these animals having a lung and breathing, is that animals of large size require an excess of heat, to facilitate[2] their motion. A lung, therefore, is placed within their body, and is fully supplied with blood-heat. These creatures are after a fashion land and water animals in one. For so far as they are inhalers of air they resemble land-animals, while they resemble water-animals in having no feet and in deriving their food from the sea. So also seals lie half-way between 697b land and water animals, and bats half-way between animals that live on the ground and animals that fly; and so belong to both kinds or to neither. For seals, if looked on as water-animals, are yet found to have feet; and, if looked on as land-animals, are yet found to have fins.[3] For their hind feet are exactly like the fins of fishes; and their teeth also are sharp and interfitting[4] as in fishes. Bats again, if regarded as winged animals, have feet; and, if regarded as quadrupeds, are without them.[5] So also they have neither the tail of a quadruped nor the tail of a bird; no quadruped's tail, because they are winged animals; no bird's tail, because they are terrestrial. This absence of tail is the result of necessity. For bats fly by means of a membrane, but no animal, unless it has barbed feathers, has the tail of a bird; for a bird's tail is composed of such feathers.

[1] As to continuity of brain and spinal cord, and its supposed purpose, cf. ii. 7. 652^a 30.

[2] Heat is the instrument of the soul in motion, as in all operations. Cetacea, therefore, that move actively must have much heat; and this again necessitates a perfect organ to regulate heat, and such is the lung.

[3] For πτέρυγας read πτερύγια.

[4] *H. A.* ii. 1. 501^a 21. In the seals, says Owen (*Odontog.* i. 506), 'the coadaptation of the crowns of the upper and lower teeth is more completely alternate than in any of the terrestrial Carnivora, the lower teeth always passing into the interspace anterior to its fellow in the upper jaw.'

[5] A. means that the anterior limbs of bats though they are wings yet have claws, and so resemble feet and are unlike the wings of a bird; but at the same time they do not so closely resemble the fore-limbs of a quadruped as to make the bat strictly quadrupedous. A. knew that bats are viviparous and suckle their young; for he speaks of these animals as having cotyledons in their uterus (*H. A.* iii. 1. 511^a 31 sq.), and groups them with the hare and the rat among viviparous animals with teeth in both jaws.

As for a quadruped's tail, it would be an actual impediment, if present among the feathers.

Much the same may be said also of the Libyan ostrich. **14**
For it has some of the characters of a bird, some of the characters of a quadruped. It differs from a quadruped in being feathered; and from a bird in being unable to soar aloft, and in having feathers that resemble hair and are useless for flight.[1] Again, it agrees with quadrupeds in having upper eyelashes,[2] which are the more richly supplied with hairs because the parts about the head and the upper portion of the neck are bare;[3] and it agrees with birds in being feathered in all the parts posterior to these. Further, it resembles a bird in being a biped, and a quadruped in having a cloven hoof; for it has hoofs and not toes.[4] The explanation of these peculiarities is to be found in its bulk, which is that of a quadruped rather than that of a bird. For, speaking generally, a bird must necessarily be of very small size. For a body of heavy bulk can with difficulty be raised into the air.

Thus much then as regards the parts of animals. We have discussed them all, and set forth the cause why each exists; and in so doing we have severally considered each group of animals. We must now pass on, and in due sequence must next deal with the question of their generation.

[1] In the ostrich and other Ratitae the barbs of the feathers are disconnected, so that they come to resemble long hairs, and, owing to their want of firmness, are useless for flight.

[2] Cf. ii. 14. 658^a 13 note.

[3] The head and neck are naked, or covered with only a short downy plumage. Cf. ii. 9. 655^a 28 note.

[4] The foot of the ostrich has two stout toes, connected at the base by a strong membrane. Of these toes, the internal is much the larger, and is furnished with a thick hoof-like claw, but the external and smaller toe is clawless. Aristotle had probably never himself seen an ostrich; for, had he done so, he would scarcely have spoken of its foot as having two hoofs. That the ostrich is a kind of link, uniting birds with mammals, is not a fancy confined to Aristotle. The vulgar opinion in Arabia still makes it the product of a camel and a bird, as in the days when it got the name, already used for it by Pliny, of Struthio-camelus. The height of the bird, its long neck, its bifid foot, its frequentation of the desert, its patient endurance of thirst, and possibly the comparative complexity of its digestive organs, were doubtless the grounds of this strange notion.

INDEX

39^a—97^b = 639^a—697^b

The English version clearly cannot tally line for line with the Berlin Greek text; it tallies, however, pretty closely with it at the lines marked 5, 10, 15 &c. In the following Index, the matter intervening between two consecutive figures, say 10 and 15, is regarded as a section, and anything occurring in that section is referred to by the figure at its beginning. For instance, anything between 63^b 10 and 63^b 15 is referred to in the Index as 63^b 10.

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